LIFE12 ENV/FI/000592 UPACMIC - Utilisation of by-products and alternative construction materials in new mine construction

Final slideshow

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LIFE12 ENV/FI/000592
Ympäristöministeriö
Miljöministeriet
Ministry of the Environment
RAMBOLL
skarta
fortum
For a cleaner world
UPACMIC

PROJECT VIDEO AND WEBSITE

- Project video can be found from youtube:
  - In Finnish https://youtu.be/musHjIYNI3w
  - In English https://youtu.be/VwMSopTNfx0
- Or from project's website: https://projektit.ramboll.fi/life/upacmic/
  - All published materials are also there.

PROJECT OVERVIEW

- EU funded project, started in 2013, estimated end date 2020-2023.
- Project partners: Ramboll Finland (coordinator), Skarta (ex-Suomen maastorakentajat), Fortum Environmental Construction
- Area: secondary materials in mining sector

- Initial problem: Mine closure consumes high volumes of aggregates. Meanwhile, many industries produces suitable waste material for earth construction

PROJECT OBJECT

- Rise awareness about that utilization of alternative materials in mining environment is plausible, considerable and competitive solution.

- Utilizing alternative materials can also cut costs and save natural unrenewable resources.

MAIN REPORTS WHICH GENERATED DURING PROJECTS

Report	What can be found
A3 material testing	Material and mixture testing (in Finnish)
A4 pilot planning	Plans for pilots (in Finnish)
B1 Pilot structures	Pilots construction and follow up results (in Finnish)
B2 Logistical model	Logistical model (in Finnish)
B3 Quality control	Structures afterlife monitoring and LCA calculations (in English)
Laymans report	Simplified roundup (in Finnish and in English)
Best methods	Roundup about best methods and materials for each structure (in Finnish and in English)

PROJECT TARGETS

- Development and piloting of suitable alternative material mixtures for:
  - Cover layers
  - Bottom sealing layers
  - Reactive barriers

- Monitoring of the impact of the project actions
  - Evaluation of the results from environmental and technical monitoring
  - Best practices learned from the project are put together into the guideline

- Piloting has been carried out in Pyhäsalmi and Hitura mines and Sorsasalo landfill in Finland

By-products from various industries

Waste gypsum

Fibre clay (deinking sludge)

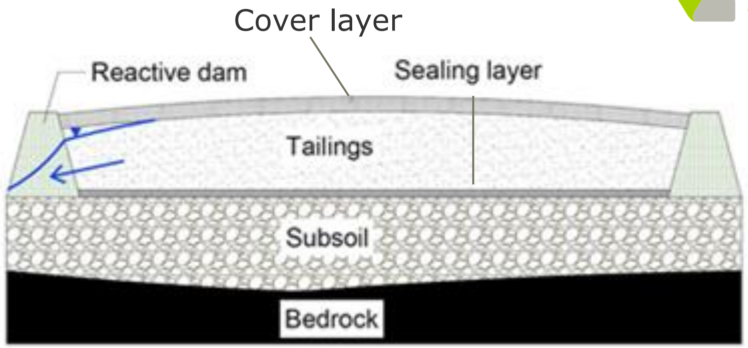
Biomass fly ash

Waste lime

Anaerobic digestion residue

Foundry sand

New materials for mine construction



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DESIGNING PROCESS

Local material survey about those possibilities and limits (availability, quantity, quality, costs, timetable…)

Laboratory testing and designing (technical propeties and environmental suitability)

Pilot testing in field conditions (most potential materials for structures)

Full scale pilot construction (Best material for structure)

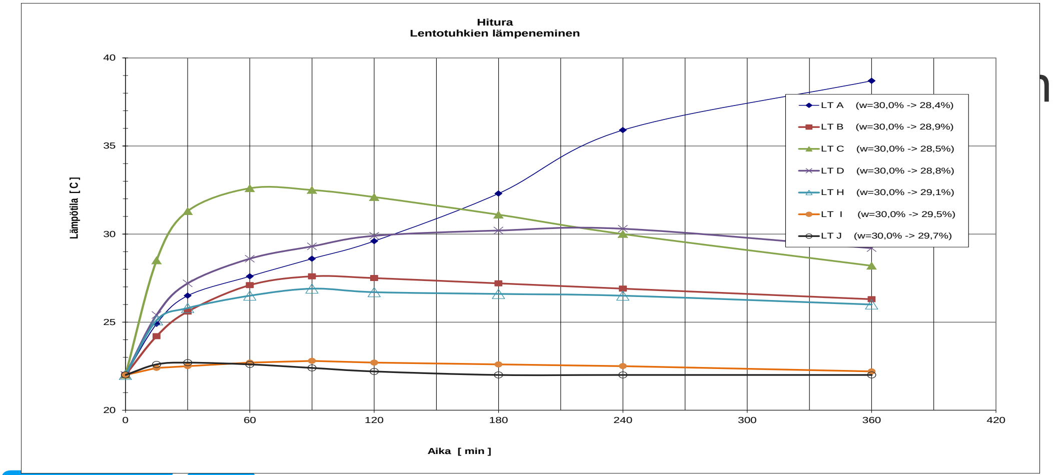
MATERIAL TESTING

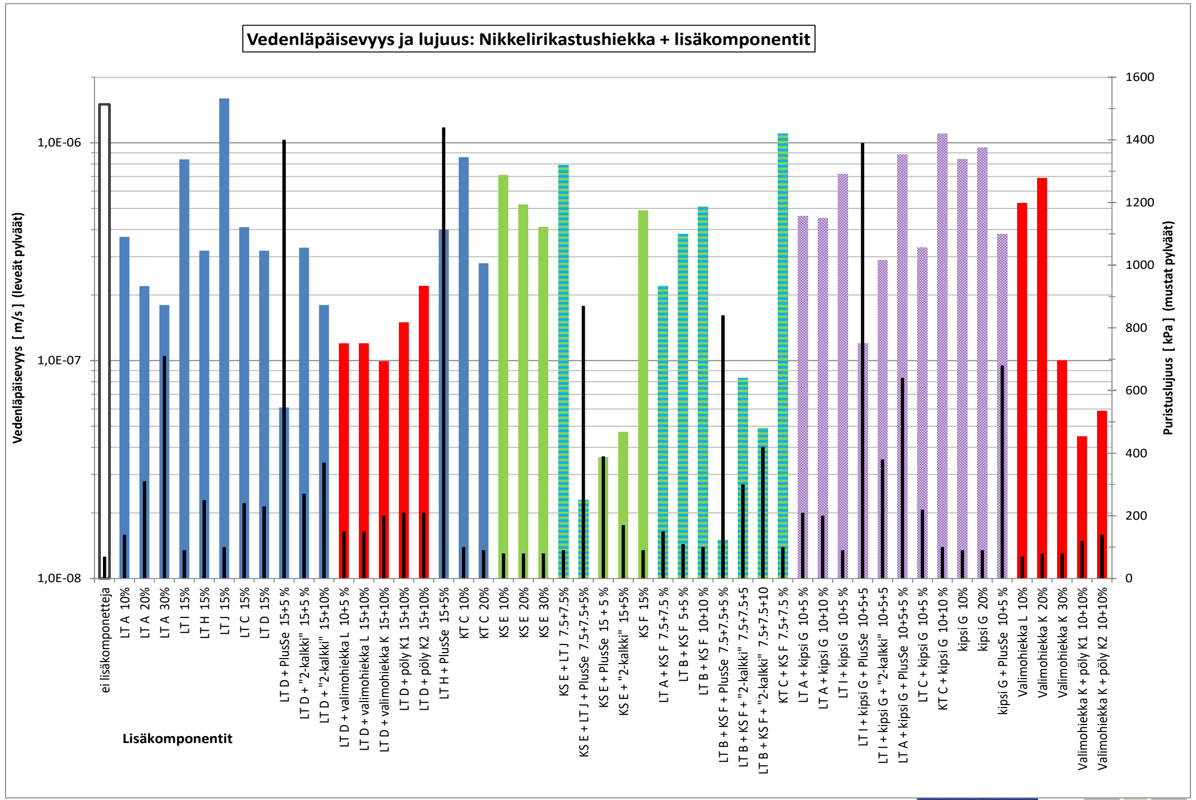
MATERIAL TESTING – METHODS

- Classification / quality & quality control:
  - Water content
  - Loss on ignition
  - pH
  - granularity
  - Reactivity/warming feature
  - Amount of reactive calcite
- Compression strength
- Water permeability
- Hardiness
- Ground frost rising test
- Solubility test
- Filtration test

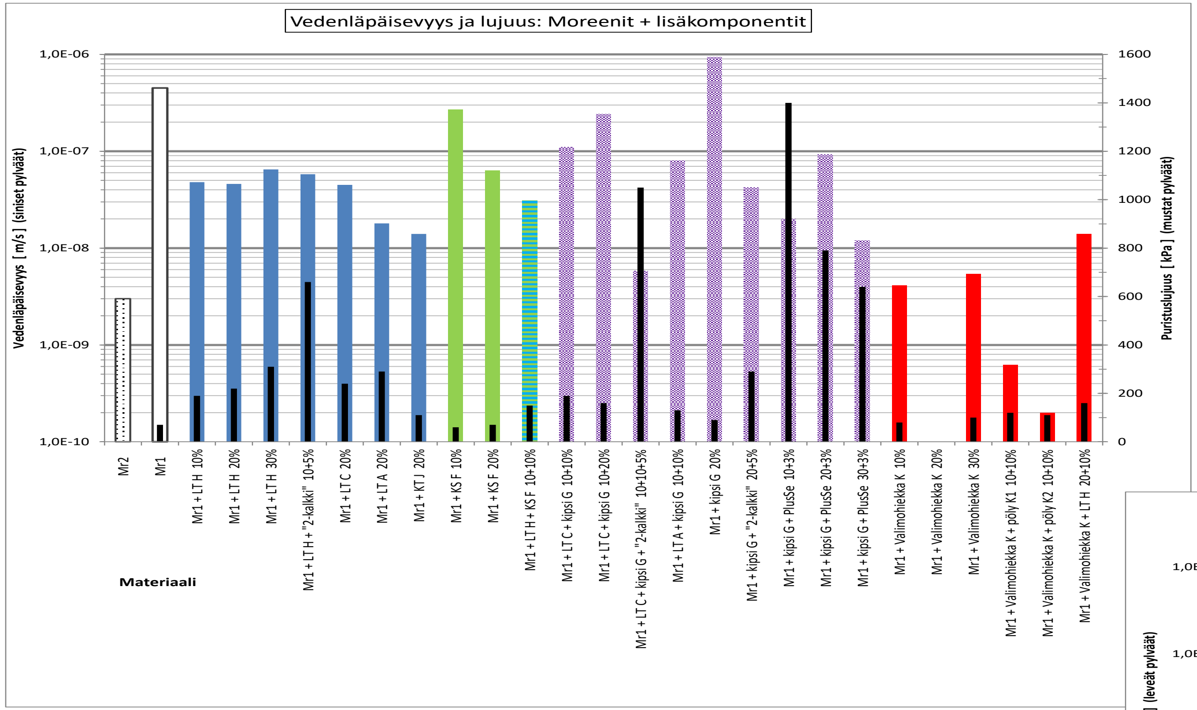
MATERIAL TESTING – FIRST PHASE TESTS

- Nickel enrichment sand as aggregate
- Moraine as aggregate
- Gold enrichment sand (Kopsa) as aggregate
- Side stream mixtures



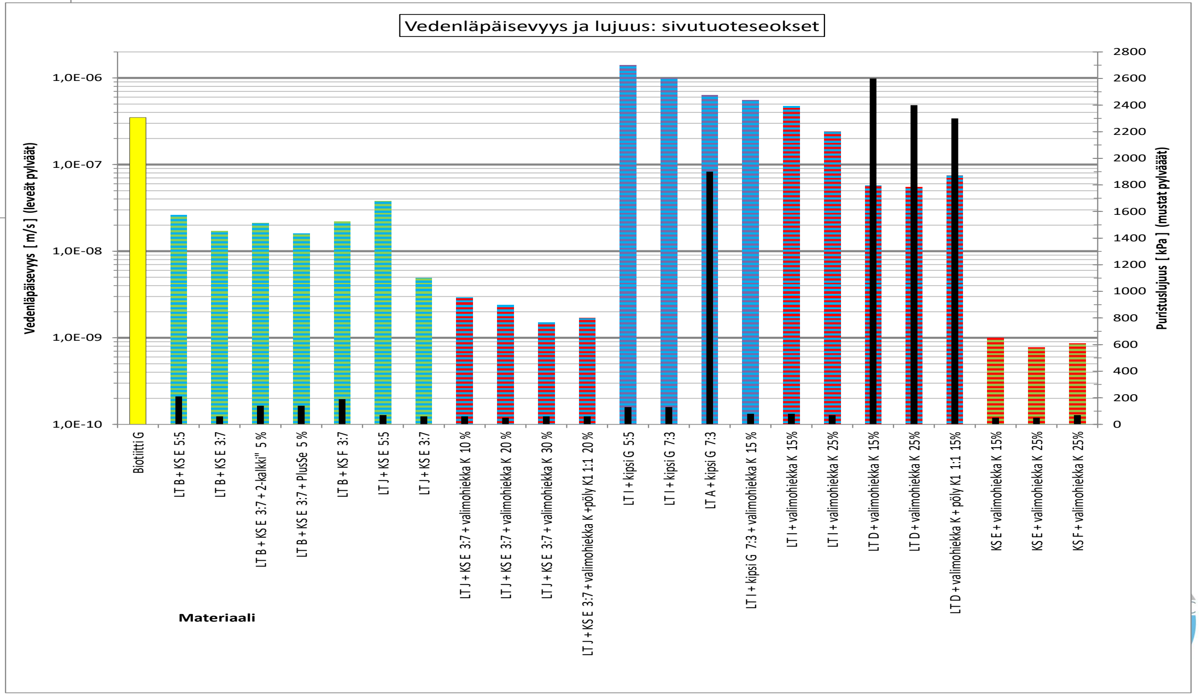


MATERIAL TESTING – FIRST PHASE TESTS



Moraine as aggregate

Side stream mixtures



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MATERIAL TESTING – FIRST PHASE TESTS

Aggregate	Seoskomponentit	Water permeability (m/s)	Compression strength kPa
Nickel enrichment sand	Fly ash + cement (15+5 %)	$<10^{-7}$	≈1400
	Fibre clay (10-30 %) Fibre clay + binder	hint $>1x10^{-7}$ $<10^{-7}$	<100 150…400
	Foundry sand + dust (10 + 10 %)	$1x10^{-8}…1x10^{-7}$	70–200
Poor quality moraine	Foudry sand + dust (10+10 %)	$<1x10^{9}$	100
	Ash (10-30 % varrying quality)	almost $1x10^{-8}$	100-300
	Ash + gypsum + lime (10+10+5 %)	$< 1x10^{-8}$	1000

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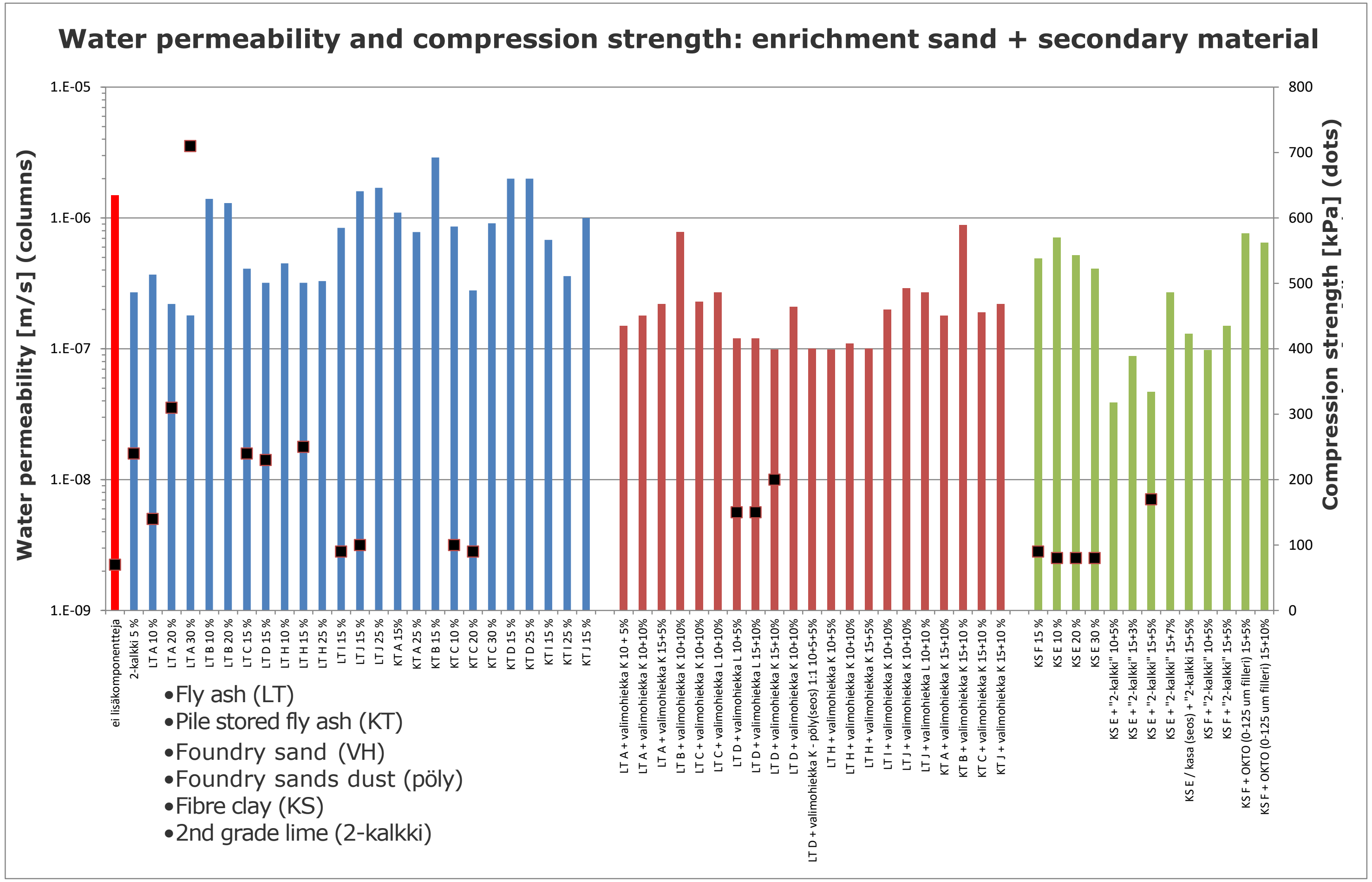
MATERIAL TESTING – SECOND PHASE TESTS

- 2nd phase of material testing the main objective was research how different side stream materials from different facilities effects constructing quality and how much it can be varying.

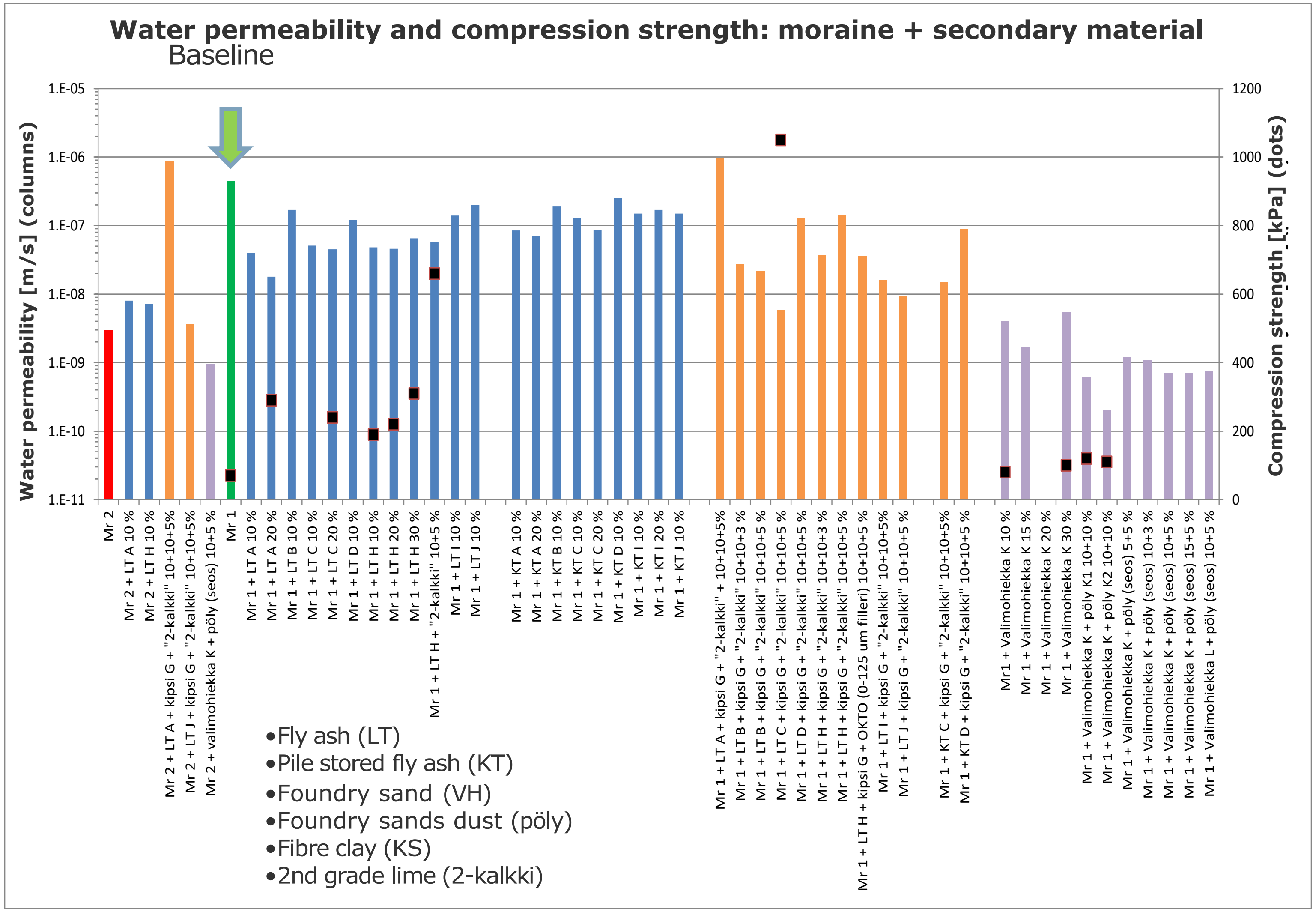
- In the research also aimed to classified material batch that can be utilised as building material, which make possible to estimate amount of available resources.

- For follow-up research was picked different kind of structures so the accumulated information about materials features which can be then utilised as wide variety of structures and applications as possible.

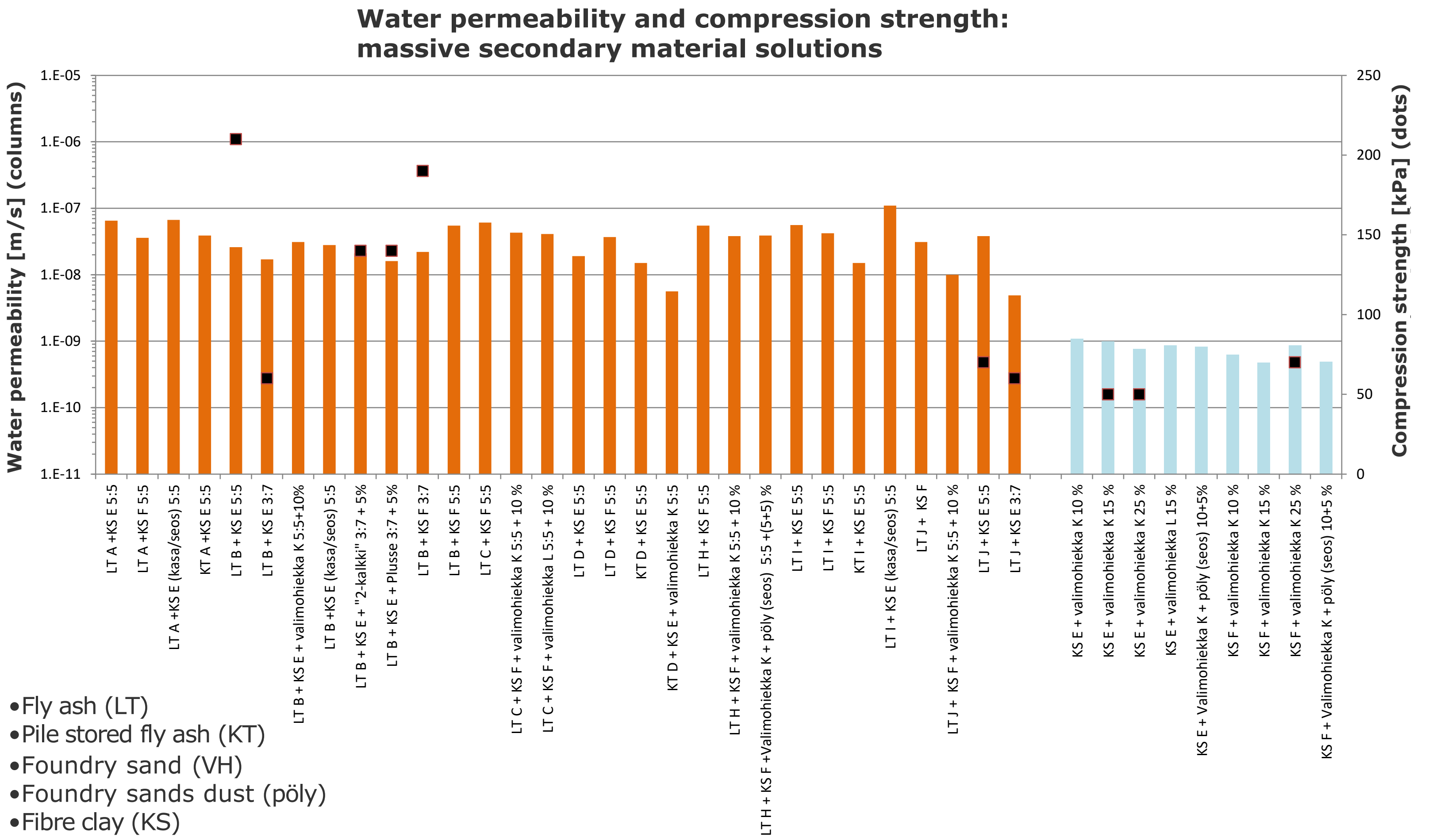
MATERIAL TESTING – SECOND PHASE TESTS / NICLE ENRICMENT SAND



MATERIAL TESTING – SECOND PHASE TESTS/ MORAINE



MATERIAL TESTING – SECOND PHASE TESTS/ SECONDARY MATERIALS



- Fly ash (LT)
- Pile stored fly ash (KT)
- Foundry sand (VH)
- Foundry sands dust (pöly)
- Fibre clay (KS)
- 2nd grade lime (2-kalkki)

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IMPROVING WATER PERMEABILITY VALUE

- From enrichment sand basins sealing structures is often demanded following water permeability value

  $k < 1x10^{-8} \dots 1x10^{-9}$ m/s.

  - Nearby natural soils may not fulfil that demand or amount of them is limiting factor.

- Low quality soils properties can be improved by adding and mixing extra component in it.

  - The extra component can be for example: fly ash, lime, bentonite dust from foundry sand and foundry sand.

  - If local soils properties can be improved to match demands, massive mass transfer can be avoided.

- Constructing sealing layer structure with a secondary products from industry will save natural soils.

  - In best case scenario the stored material can be used as part of final sealing structure.

SOME EXAMPLES WHAT CAN BE ACHIEVED BY ADDING EXTRA COMPONENT

Water permeability k (m/s)	Material mixture
≈ $5x10^{-7}$	• Nickel enrichment sand with fly ash
≈ $1x10^{-7}$	• Nickel enrichment sand with fly ash and foundry dust • Moraine with pile stored fly ash
≈$1x10^{-7}$…$5x10^{-8}$	• Nickel enrichment sand with fibre clay & lime • Moraine with fly ash
≈ $1x10^{-8}$	• Moraine with ash-gypsum-lime mixture
≈$1x10^{-8}$…10^{-9}	• Moraine with foundry sand • Fibre clay layer
≤$1x10^{-9}$	• Moraine with foundry dust • Fibre clay with foundry sand
compressive strength (kPa)	
50-100	• Fibre clay (+foundry sand), break > 15 %
100-300	• Moraine with foundry sand • Nickel enrichment sand with fly ash and foundry dust • Nickel enrichment sand with fibre clay & lime • Moraine with fly ash
>500	• Nickel enrichment sand with large amount of fly ash • Moraine with ash-gypsum-lime mixture

TESTED MATERIALS AND THEIR SUITABILITY

UPACMIC - LIFE12 ENV/FI/000592

19.12.2019

A 3. Material matrix for mining operations

	Material	Tested in laboratory	Tested in field	Material technical suitability for different structure types			Material environmental suitability for different structure types			Comments
				Cover structure	Bottom structure	Reactive barrier	Cover structure	Bottom structure	Reactive barrier	
Fibre clays	KJ M (Fiber clay 1)	x	x	++	+	-	++	++	+	4 different fibre clay has been tested in laboratory for cover and bottom structures and reactive barriers. The suitability for cover structures has been verified in field tests (3 different type) and it is suitable for cover structures. The low permeability tested in laboratory enables also the use in bottom structures. The achievable permeability depends on the material properties (e.g. density, level of compaction and water content. Water permeability < 1 x 10-8 m/s was achieved with all tested materials but lower requirements can be difficult to achieve. Low waterpermeability can be problematic for reactive barriers as the water flow throuhg the material is slow. The material properties varies between different factories therefore the material tests are essential before use.
	KJ N (Fiber clay 2)	x	x	++	+	-	++	++	+	
	KJ E (Fiber clay 3)	x	x	++	+	-	++	++	+	
	KJ F (Fibre clay 4)	x		++	+	-	++	++	+	
Dry fly ashes	LT C (Biomass & peat fly ash)	x	x	++	-/+	+	+	+	0	Various fly ash grades was tested for cover structure purposes. Fly ash was tested alone as well as mixed with enrichment sand and moraine. The k-values for all tested fly ash mixtures were above 10^{-8} m/s, which may preven the use of material in bottom structures where typical requirements are 10^{-8} - 10^{-9} m/s. The alkaline fly ash can function as neutralizer for acid mine drainage if used in cover layers or reactive barriers and it can precipitate many metals. The environmental properties and possible joint effects needs to be studied case by case as leachability of certain heavy metals can increase with some fly ashes. In addition, the technical suitability needs to be studied case by case as there were a lot of variety in the results with differend fly ash grades.
	LT I (Biomass & peat fly ash)	x		+	-/+	+	0	0	0	
	LT A (Biomass & REF fly ash)	x		++	-/+	+	-/+	-/+	-/+	
	LT H (Biomass & peat fly ash)	x		++	-/+	+	+	+	0	
	LT D (Biomass & REF fly ash)	x		++	-/+	+	0	0	0	
	LT B (Biomass & Peat fly ash)	x		++	-/+	+	+	+	0	
Piled fly ashes	KT C (Biomass & peat piled fly ash)	x		-/+	-/+	-/+	0	0	0	Piled fly ashes were in general less reactive than dry fly ashes. Therefore the technical suitability depends on the application and possible material mixture and it needs to be verified case by case. The leaching of inorganic components from pile stored fly ashes usually decreases over time which increases the environmental suitability.
	KT I (Biomass & peat piled fly ash)	x		-/+	-/+	-/+	0	0	0	
	KT A (Biomass & REF piled fly ash)	x		-/+	-/+	-/+	0	0	0	
	KT D (Biomass & REF piled fly ash)	x		-/+	-/+	-/+	0	0	0	
	KT B (Biomass & Peat piled fly ash)	x		-/+	-/+	-/+	0	0	0	
	KT J (Biomass piled fly ash)	x		-/+	-/+	-/+	0	0	0	
Foundry sands	Foundry dust 1 (Bentonite sand process)	x		+	+	0	-	-	-	Tested foundry sands contained bentonite. Mixing of foundry sands (10%) with moraine it was possible to achieve lower water permeability compared to moraine itself. Achieved permeability values of moraine-foundry sand mixtures varied in laboratory tests between 5,4 x 10^{-9} m/s - 2,0 x 10^{-10} m/s. The environmental suitability of foundry sand varies between different foundries and it needs to be verified case by case.
	Foundry sand 1 (Bentonite sand process)	x		+	+	0	-/+	-/+	0	
	Foundry sand 2 (Bentonite sand process)	x		+	+	0	-/+	-/+	0	
Gypsum	Gypsum waste (phosphogypsum)	x	x	+	0	0	+	+	0	Tested gypsum waste was found out to be suitable for cover structures. The k-value for material itself is relatively high (10^{-3} - 10^{-4} m/s), which needs to take into account in design.
Lime	Lime waste (2nd grade burnt lime)	x		+	+	+	+	+	+	Lime waste was found out to be suitable material, usually mixed with other materials, for all tested applications.

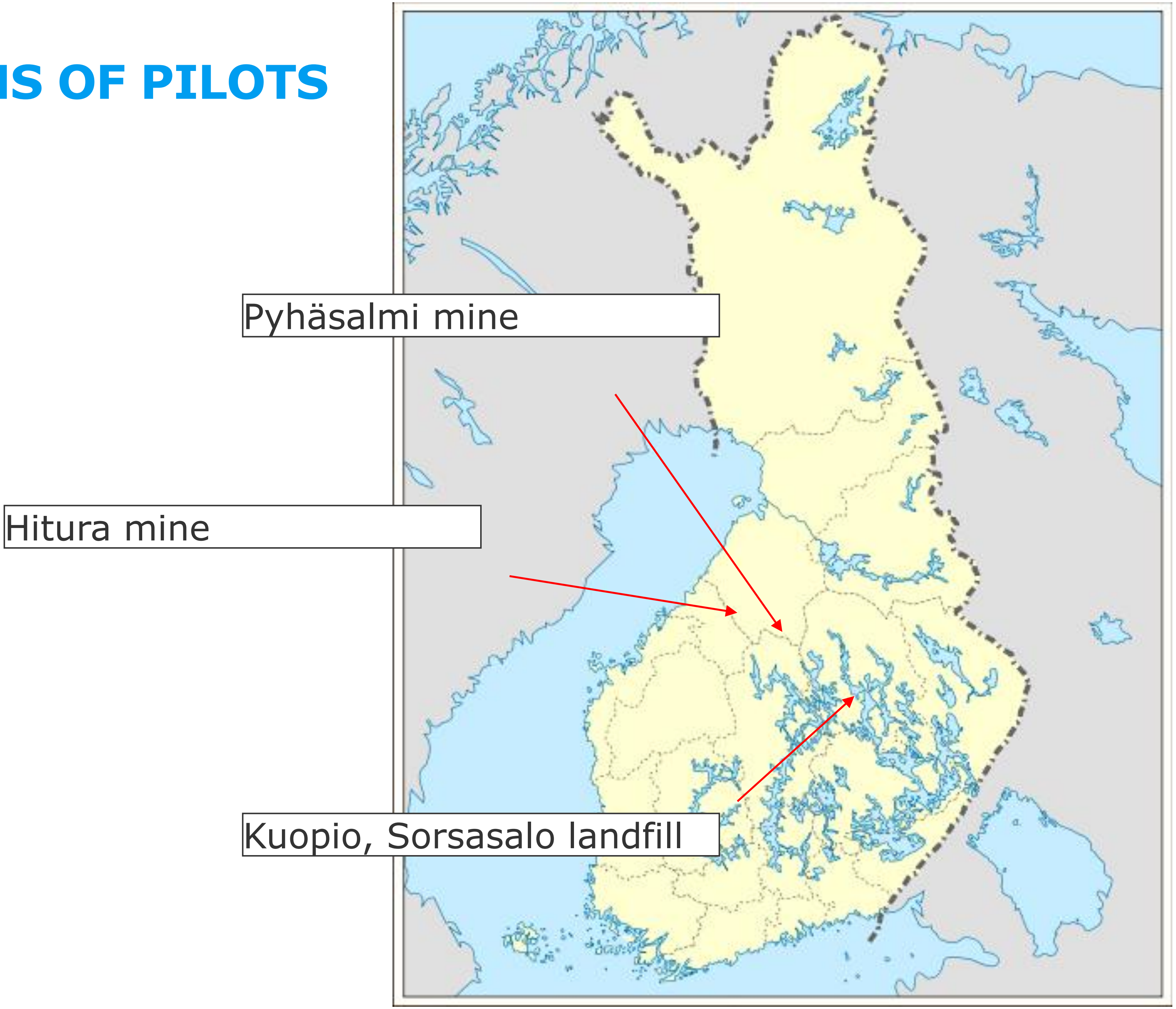
Abbreviations e.g. LT A refers to materials in deliverable "A3. Final techical report"

-	Not suitable
0	Not tested

-/+	Uncertain
+	Suitable with some exceptions
++	Suitable

PILOTING & FOLLOW UP

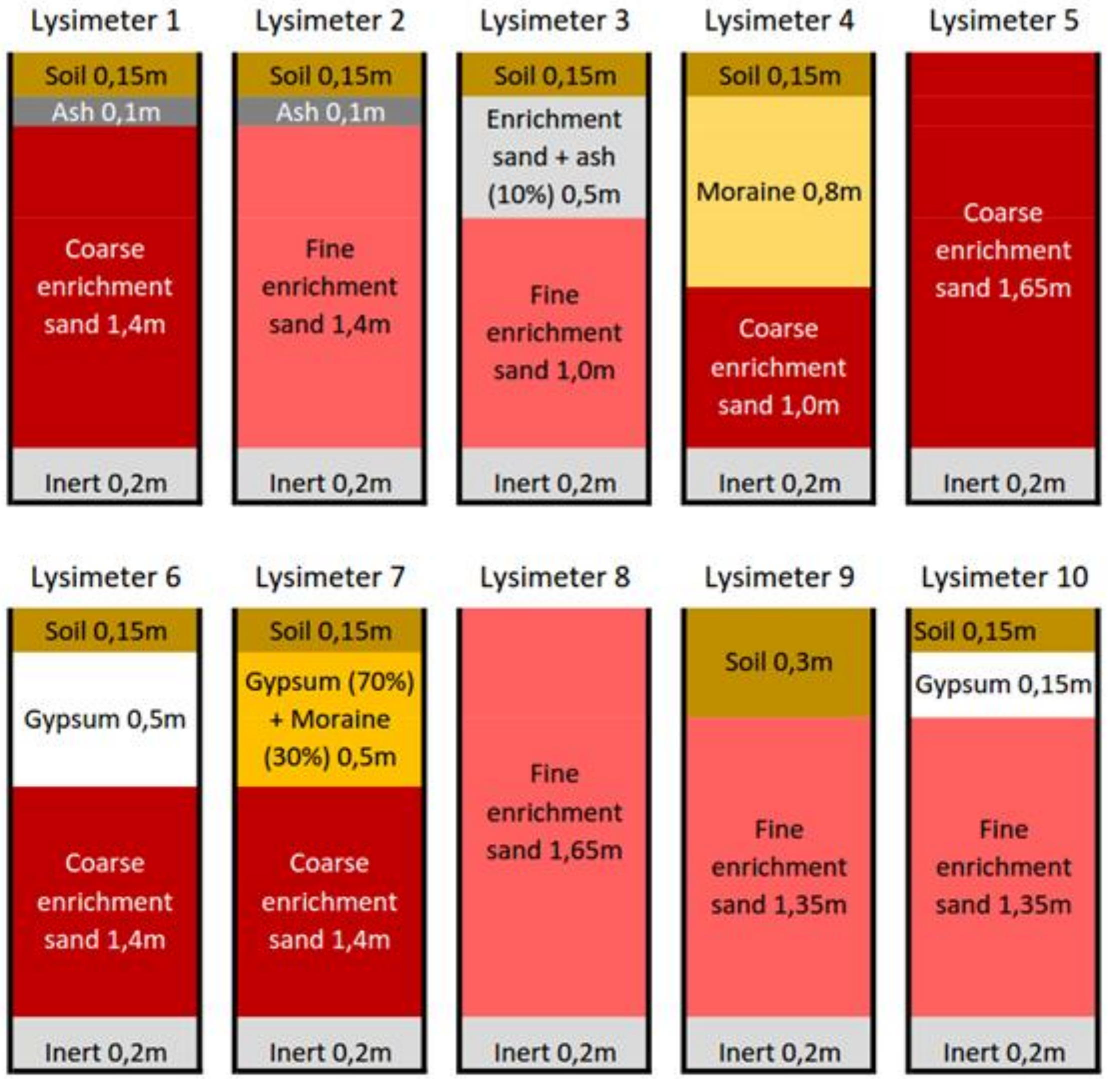
LOCATIONS OF PILOTS



RAMBOLL

OPEN TOP TANK TESTS IN PYHÄSALMI, MATERIALS

- 5 different cover layer structures were tested for both coarse and fine enrichment sands (each volume 10 m^3)
- Tested cover structure alternatives were selected based on preliminary laboratory results
- Fly ash was used for neutralising purpose
- Gypsum waste was selected for the tests because of its good availability (1,5 million tones produced annually).



RAMBOLL

OPEN TOP TANK TESTS IN PYHÄSALMI, MATERIALS

- Enrichment sand consists mainly on sulfide minerals (pyrite, baryte and pyrrhotite) and smaller amounts (<5%) of silicate minerals e.g. plagioclase, quarz and olivine
- Some burnt lime have been added to enrichment sand after the enrichment process to prevent the acid generation
- Moraine was sieved (<60mm) local moraine from Pyhäsalmi
- Gypsum waste used in the test was from phosphor acid producing fertilizer plant
- Fly ash used in the test was from nearby power plant

Total concentrations and material properties of the used construction materials

Material	Al (mg/kg)	Cu (mg/kg)	Fe (mg/kg)	Mn (mg/kg)	Zn (mg/kg)	Ca (mg/kg)	S (mg/kg)	pH (-)	ρ_d (kg/m^3)
Enrichment sand (fine)	7180	680	297000	590	1680	25400	294000	7,0	1870
Enrichment sand (coarse)	6910	720	315000	430	2180	20700	310000	6,7	2380
Ash	52400	120	142000	2430	240	72100	12800	9,5	830
Gypsum	340	13	400	21	20	277000	215000	2,8	1290
Moraine	12800	55	17500	240	63	5040	350	4,8	2300
Inert material	11000	20	20800	190	33	6570	210	7,5	-

MATERIAL SOLUBILITIES (2-STAGE BATCH LEACHING TEST)

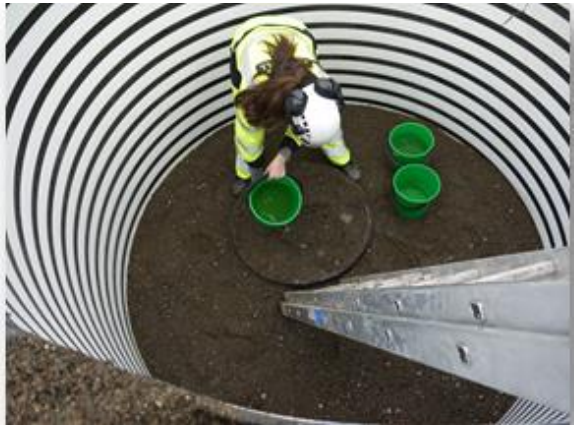
Material	Sulfate (mg/kg)	Chloride (mg/kg)	Fluoride (mg/kg)	Al (mg/kg)	As (mg/kg)	Ba (mg/kg)	Cd (mg/kg)	Cr (mg/kg)	Cu (mg/kg)	Fe (mg/kg)	Hg (mg/kg)	Mn (mg/kg)	Mo (mg/kg)	Ni (mg/kg)	Pb (mg/kg)	Sb (mg/kg)	Se (mg/kg)	V (mg/kg)	Zn (mg/kg)	Ca (mg/kg)
Moraine	280	<50	<5	0,94	<0,15	0,43	<0,015	<0,1	0,2	0,68	<0,005	5,8	<0,05	0,12	<0,15	<0,01	<0,02	<0,05	2,1	49
Gypsum	17500	<50	2190	4,1	1,5	0,06	0,049	<0,1	4,3	35,3	<0,005	17	<0,05	0,47	<0,15	<0,01	0,031	0,11	20,9	6620
Fly ash	16600	924	<5	110	<0,15	1,00	<0,015	0,5	<0,1	<0,15	<0,005	<0,1	3	<0,1	<0,15	<0,01	0,067	0,1	<0,1	6100
Coarse enrichment sand	17300	<50	6	<0,3	<0,15	0,21	0,11	<0,1	<0,1	<0,15	<0,005	54	<0,05	0,42	<0,15	<0,01	0,023	<0,05	21	6410
Fine enrichment sand	18100	<50	6,1	<0,3	<0,15	0,19	0,054	<0,1	<0,1	<0,15	<0,005	38	<0,05	0,21	<0,15	<0,01	0,02	<0,05	11	6390
Inert material	<50	<50	<5	0,63	<0,15	0,093	<0,015	<0,1	<0,1	0,56	<0,005	0,063	<0,05	<0,1	<0,15	<0,01	<0,02	<0,05	<0,1	15

OPEN TOP TANK TESTS / SETUP

- Tests monitoring period was 5/2016-8/2017
- The quality of the seepage water was monitored after 42, 134, 165, 233, 345, 375, 453/459 days. Samples were collected in one week period from lysimeter wells
- Al, As, Ba, Cd, Cr, Cu, Fe, Hg, Mn, Mo, Ni, Pb, Sb, Se, V, Zn, Ca, K, Mg, Na and S (µg/l) and also for sulfate, fluoride, chloride and DOC (mg/l) was measured from the water samples.
- Of which **Cu**, **Zn**, **Fe** and **sulfate** were main interest
- The amount of seepage water was monitored weekly

- Lysimeters were deconstructed 10/2019
  - Water samples from lysimeter and soil samples layer by layer were taken from each cylinder.






Lysimeter installation

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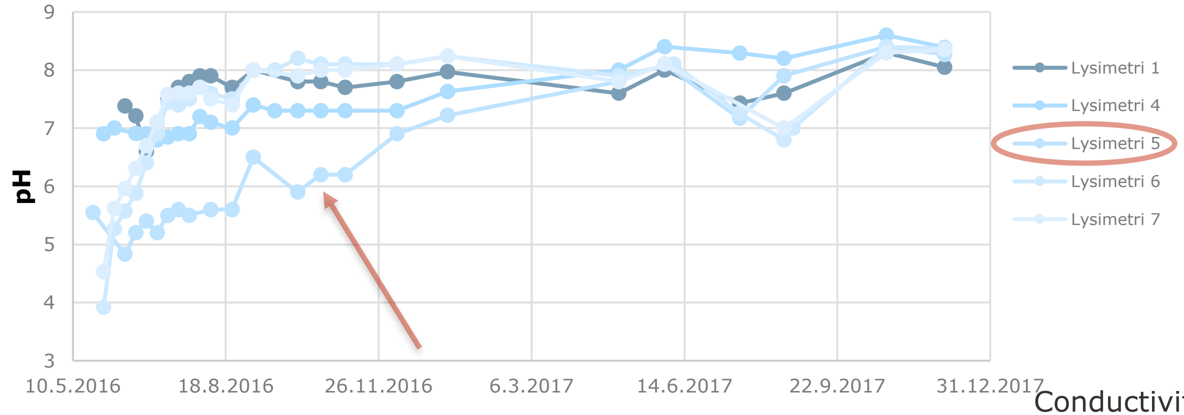
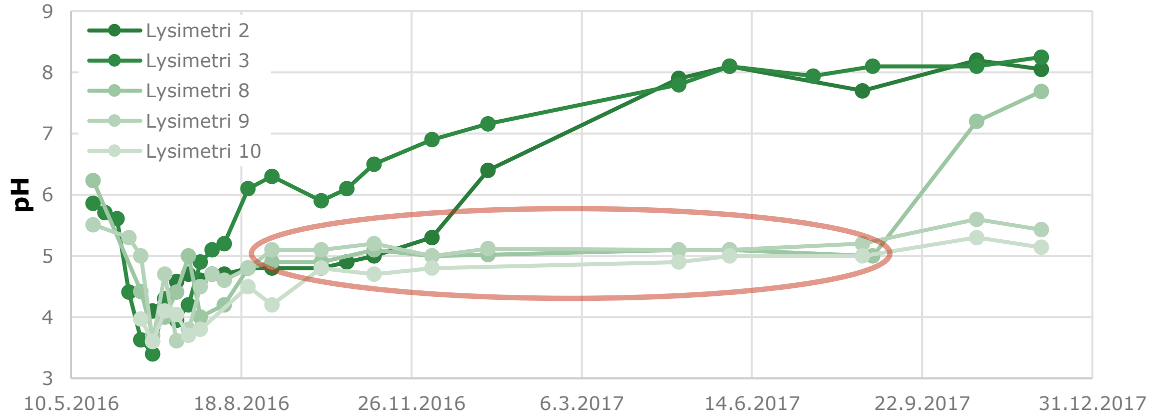
OPEN TOP TANK TESTS

Coarse enrichment sand pilot structures pH

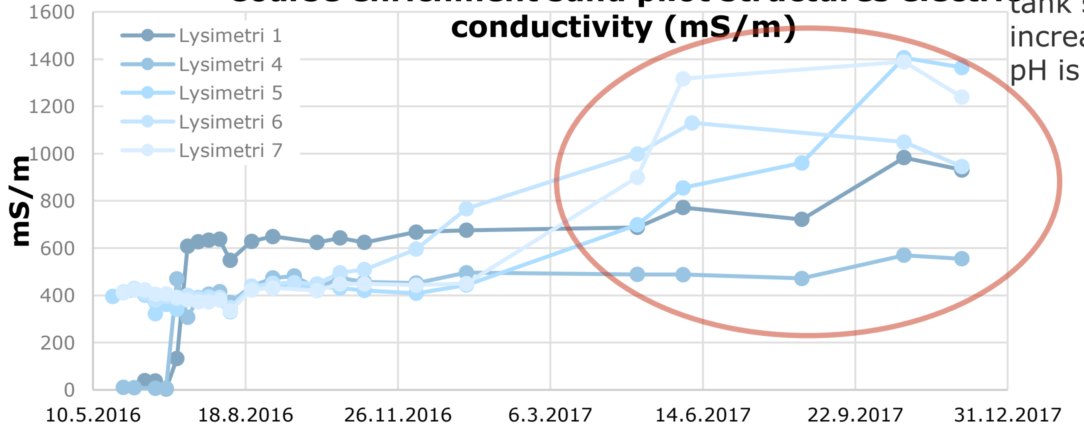


Fine enrichment sand pilot structures pH

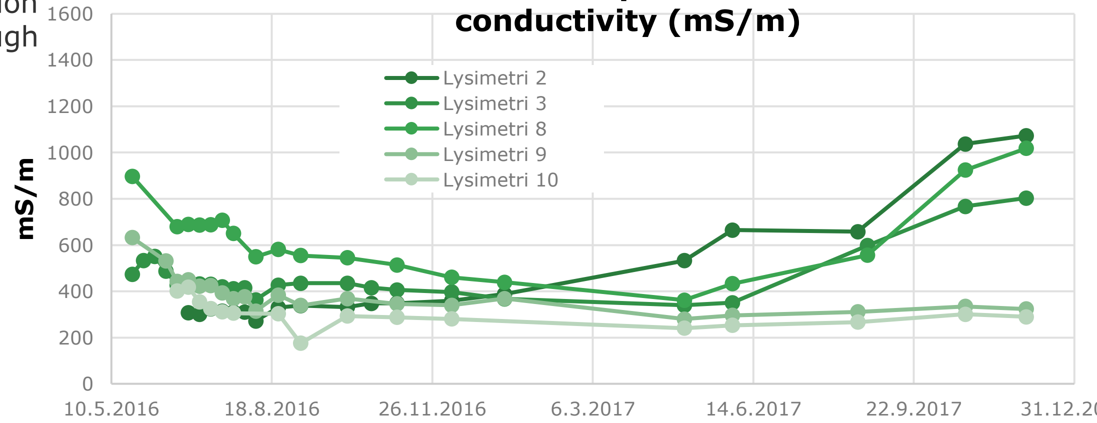


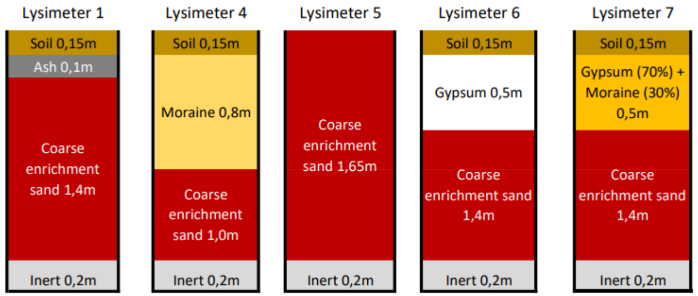
Conductivity increases in every tank so dissolution increases although pH is neutral.

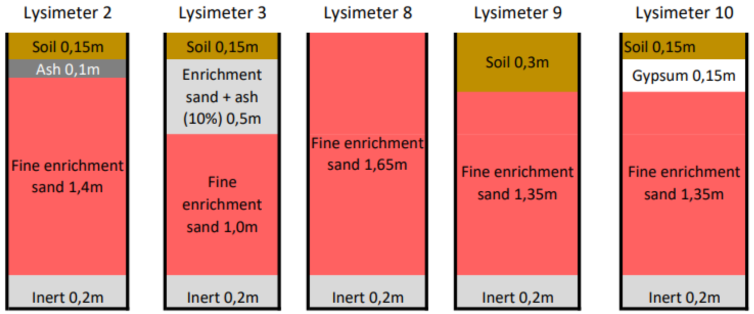
Coarse enrichment sand pilot structures electric conductivity (mS/m)



Fine enrichment sand pilot structures electric conductivity (mS/m)



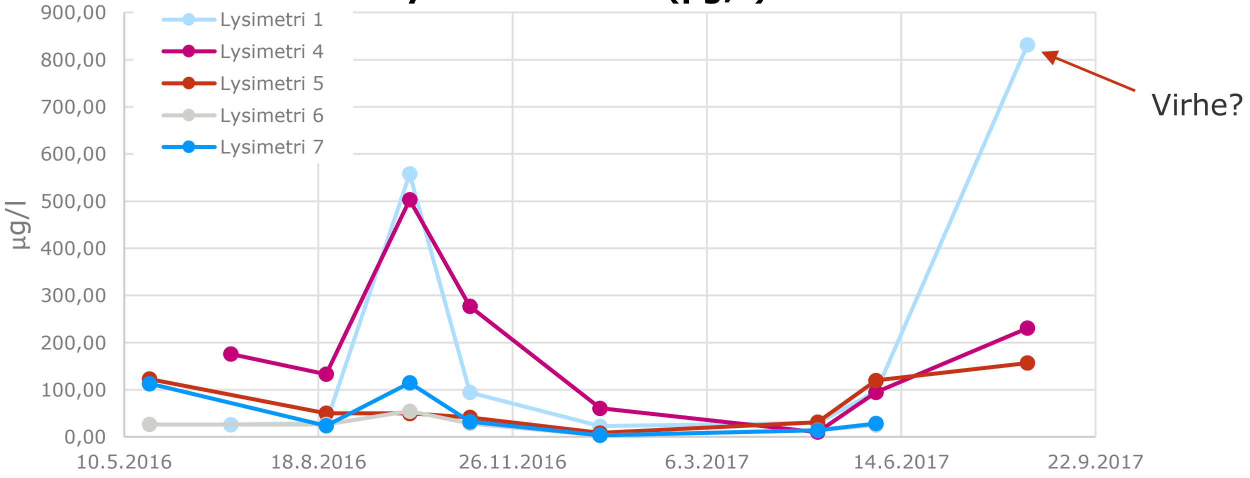




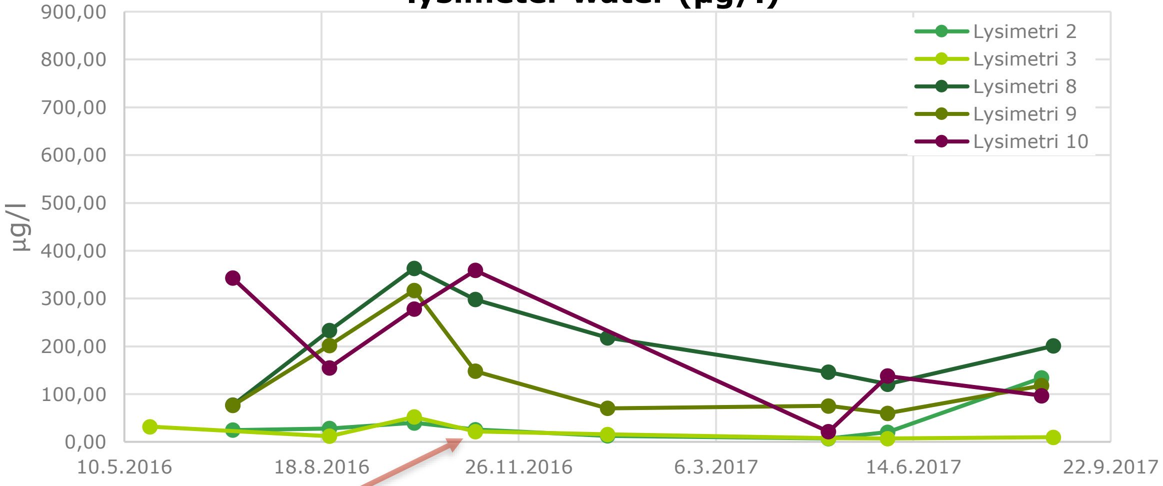
RAMBOLL

OPEN TOP TANK TESTS

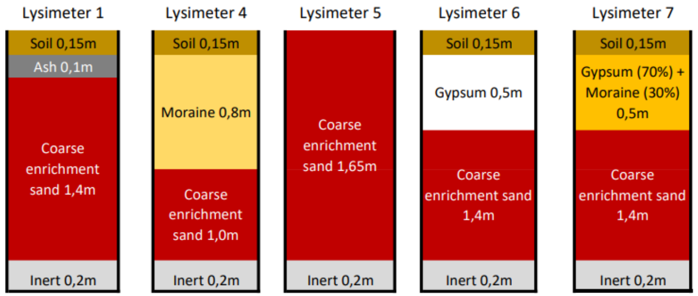
Coarse enrichment sand pilot structures dissolved zinc in lysimeter water (µg/l)

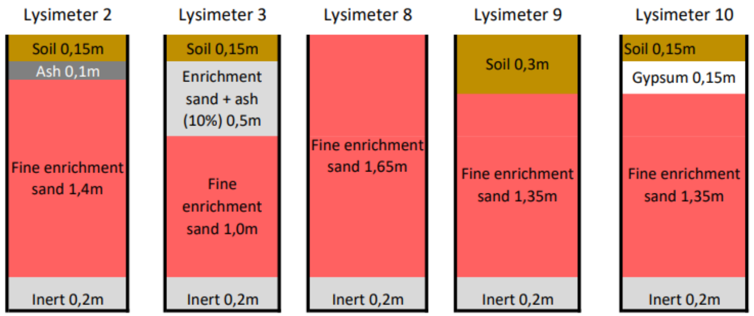


Fine enrichment sand pilot structures dissolved zinc in lysimeter water (µg/l)



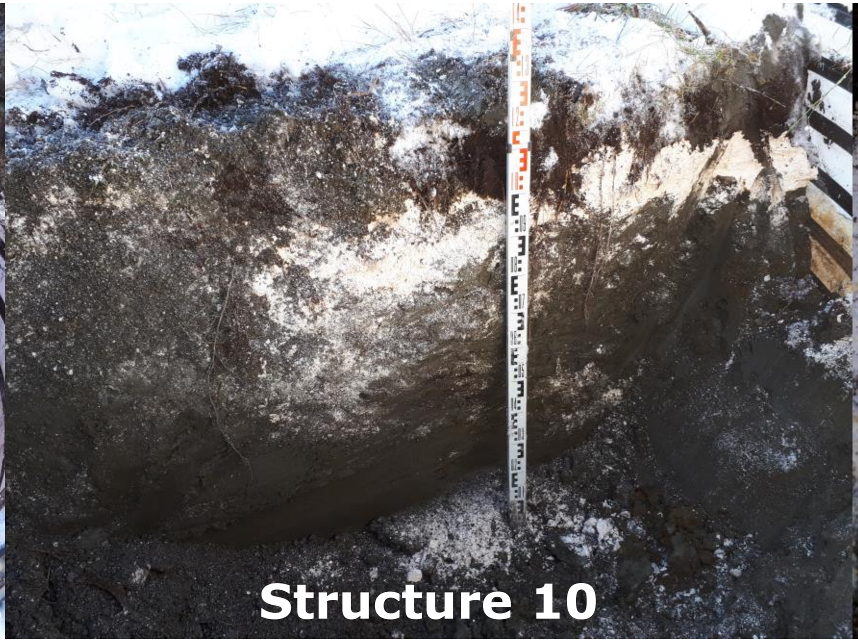
Structures 2 and 3 ash seems decreace zinc dissolution.

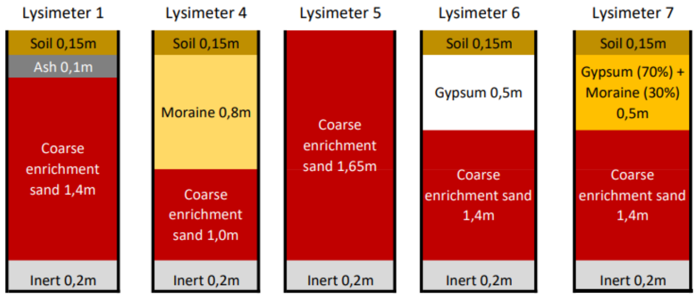


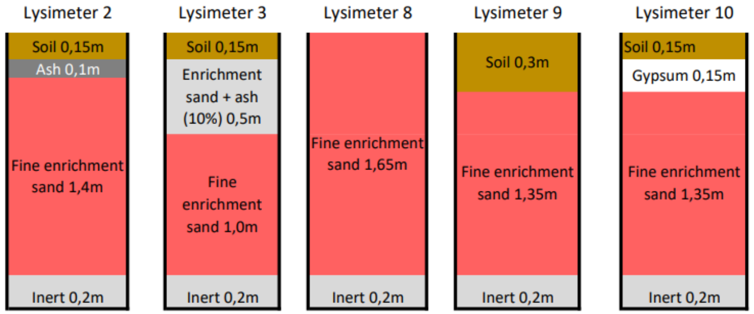


OPEN TOP TANK TESTS / TEARDOWN

5.11.2019



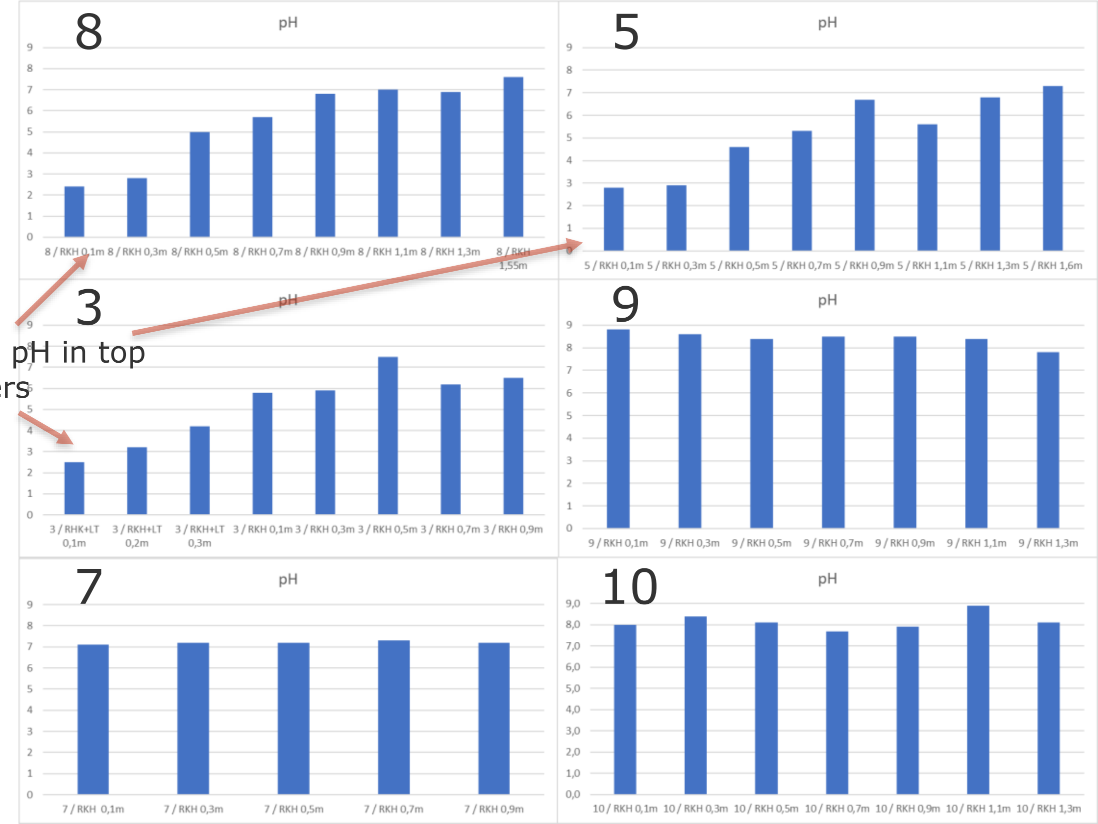


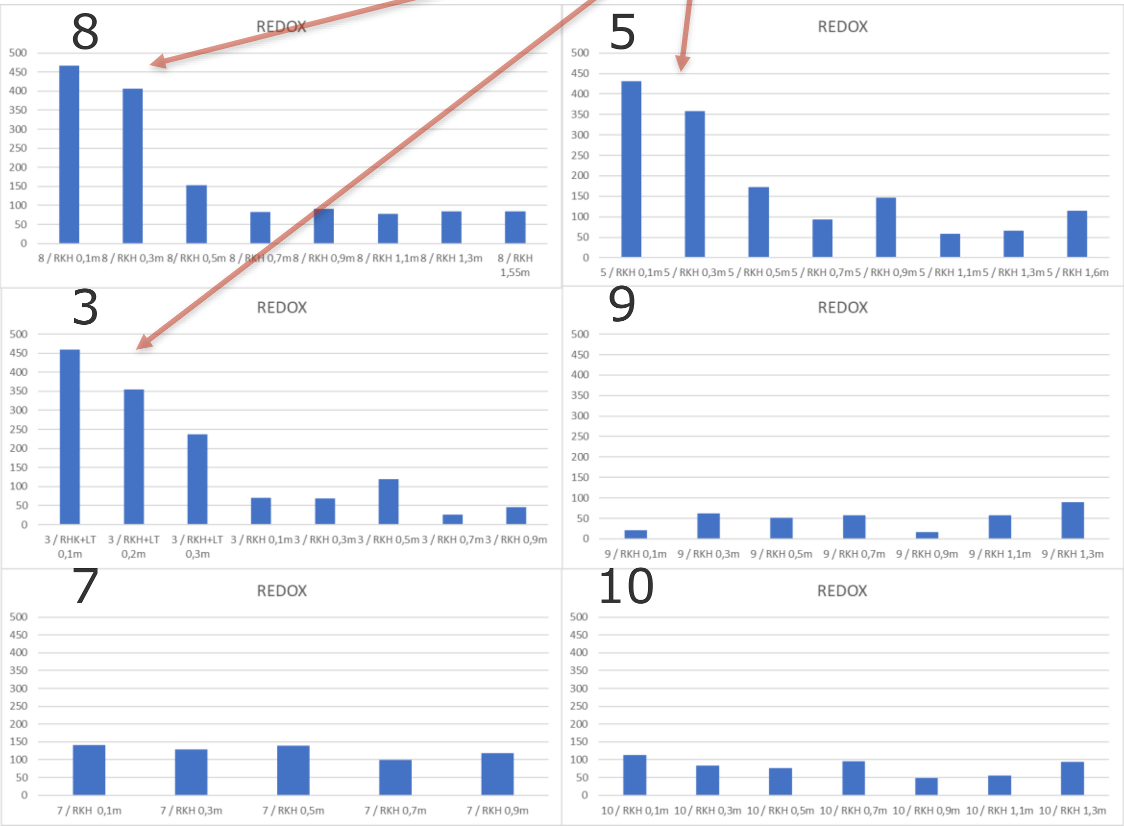


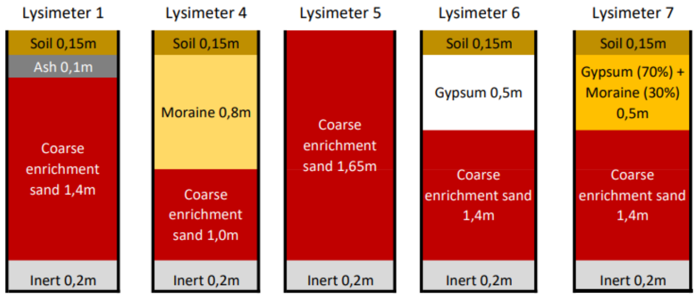
OPEN TOP TANK TESTS / LAYER SAMPLES FROM TEARDOWN

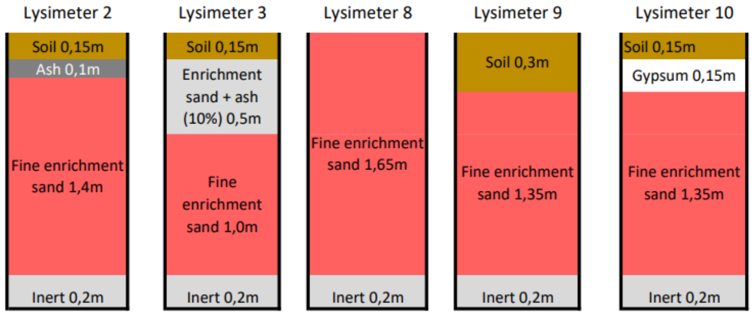
High redox-potential indicate that layers on the top is oxidised.

Low pH in top layers





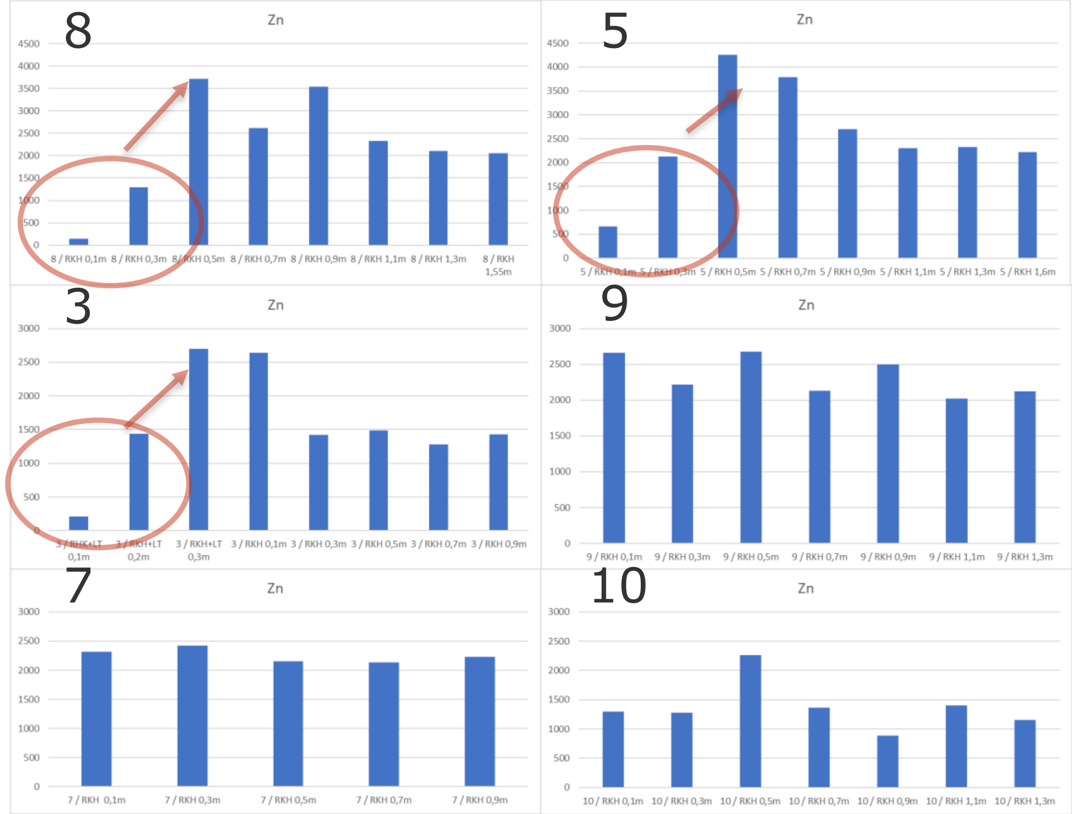




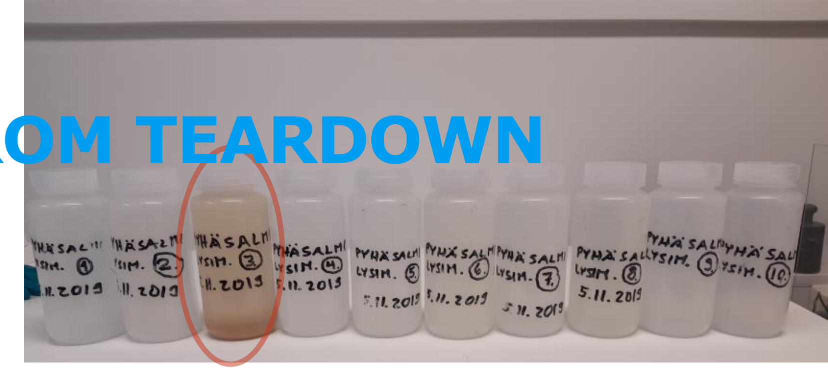
RAMBØLL

OPEN TOP TANK TESTS / LAYER SAMPLES FROM TEARDOWN

Zinc is moving deeper from oxidised top layers?



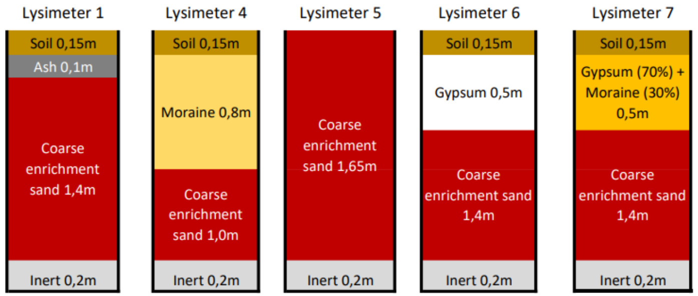
From 3rd structure is dissolved a lot iron. (explains the colour of water sample)

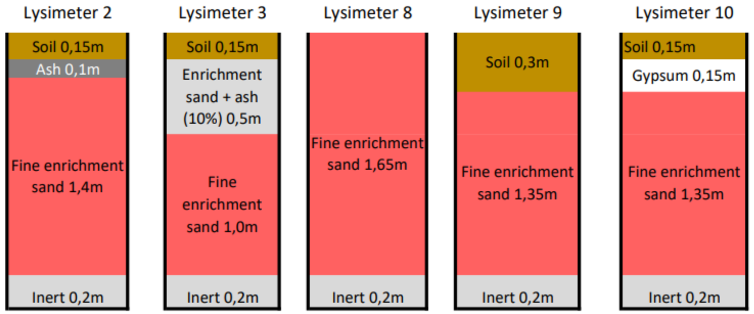


	Ph	REDOX	EC	DOC	fluoridi	kloridi	sulfaatti	Ca	K	Mg	Na	S
			[mS/cm]	mg/L	mg/L	mg/L	g/L	mg/L	mg/L	mg/L	mg/L	mg/L
Lysimeter 1	7,5	183	6,6	1,86	0,26	8,98	4,67	268	119	903	40,8	1570
Lysimeter 2	8,1	165	13,08	6,40	1,03	12,50	12	285	84,6	2390	34,5	3740
Lysimeter 3	6,6	22	16,16	11,60	<1,00	7,48	15,9	300	227	2980	71,6	4940
Lysimeter 4	8,0	131	4,78	2,16	<0,200	2,18	2,44	210	15,6	460	14,7	803
Lysimeter 5	6,5	220	9,74	4,37	<0,400	4,19	9,12	320	100	1440	33,8	2620
Lysimeter 6	8,1	166	20,2	7,79	1,19	4,54	21,5	285	74,9	4090	19	6440
Lysimeter 7	8,2	172	6,6	2,81	0,26	1,13	3,34	192	36	623	78,7	981
Lysimeter 8	7,7	184	21,5	10,10	4,67	4,41	20,5	238	115	3990	18,4	6350
Lysimeter 9	7,8	185	3,1	2,42	<0,200	15,20	1,46	298	34,7	141	33,8	484
Lysimeter 10	5,4	260	3,97	1,55	<0,200	5,90	1,17	183	43	119	198	370

	Zn	Ni	Cu	Fe	Al	Ba	Mn	V	Cd
	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Lysimeter 1	1720	40,70	2,80	<4,0	<4,00	18,40	9290	0,28	5,48
Lysimeter 2	116	<2,00	6,90	<10,0	<10,0	26,40	5180	1,98	0,25
Lysimeter 3	2050	42,20	<5,0	11600	<10,0	23,20	17200	<0,250	0,69
Lysimeter 4	64,40	<2,00	1,90	2,10	<2,00	8,80	6,48	0,96	<0,020
Lysimeter 5	5520	152	2,30	5,90	10,60	23,50	39300	<0,100	2,64
Lysimeter 6	442	4,88	<10,0	24,00	<20,0	31,10	20600	4,63	<0,200
Lysimeter 7	123	<2,00	2,20	<2,0	<2,00	15,20	170	0,69	0,04
Lysimeter 8	555	6,69	<10,0	<20,0	<20,0	22,20	12600	1,46	0,65
Lysimeter 9	120	3,18	1,50	<2,0	<2,00	17,70	783	0,21	0,19
Lysimeter 10	225	33,90	6,10	13,00	570	13,10	1160,00	0,10	1,05

RAMBØLL

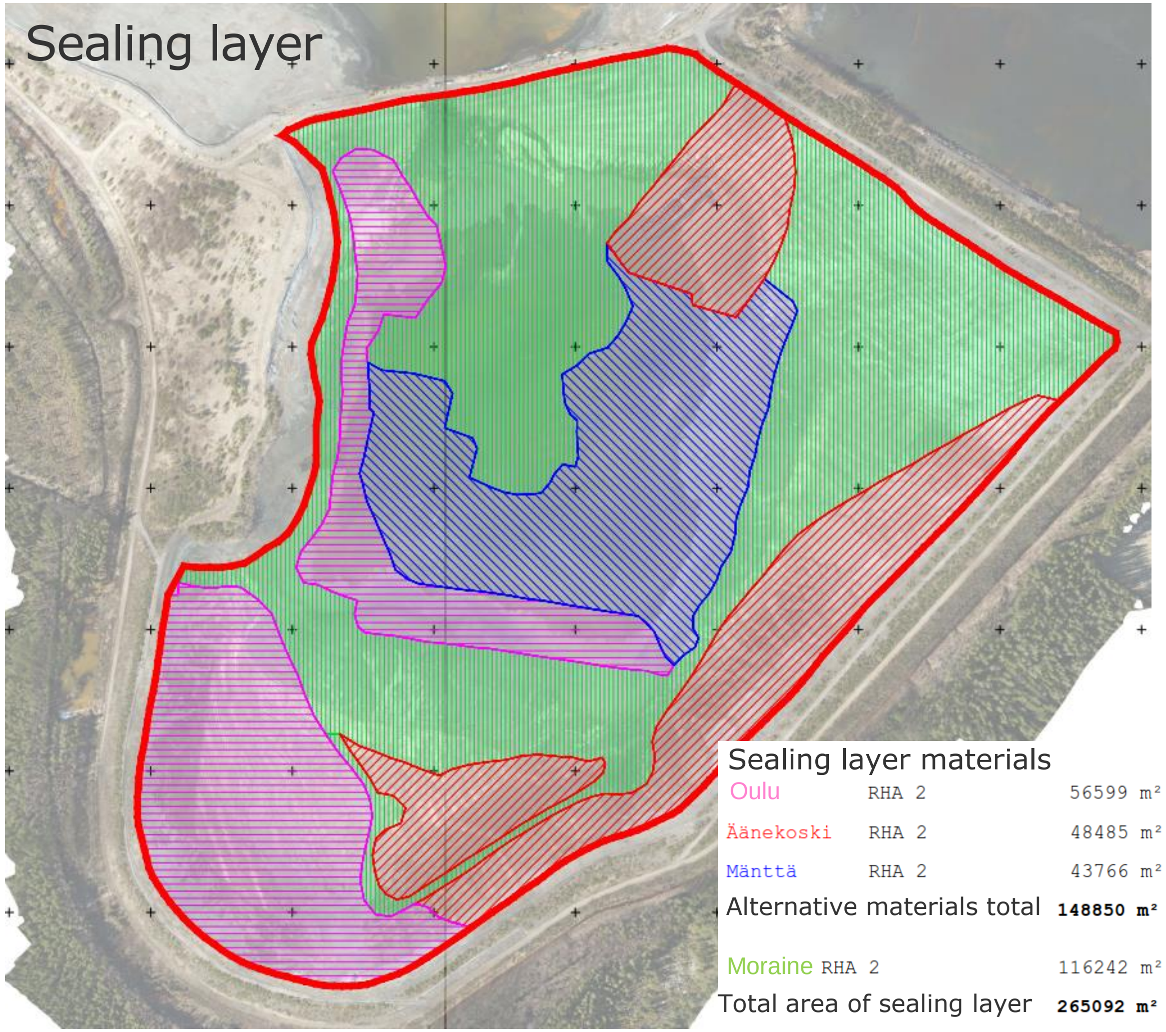


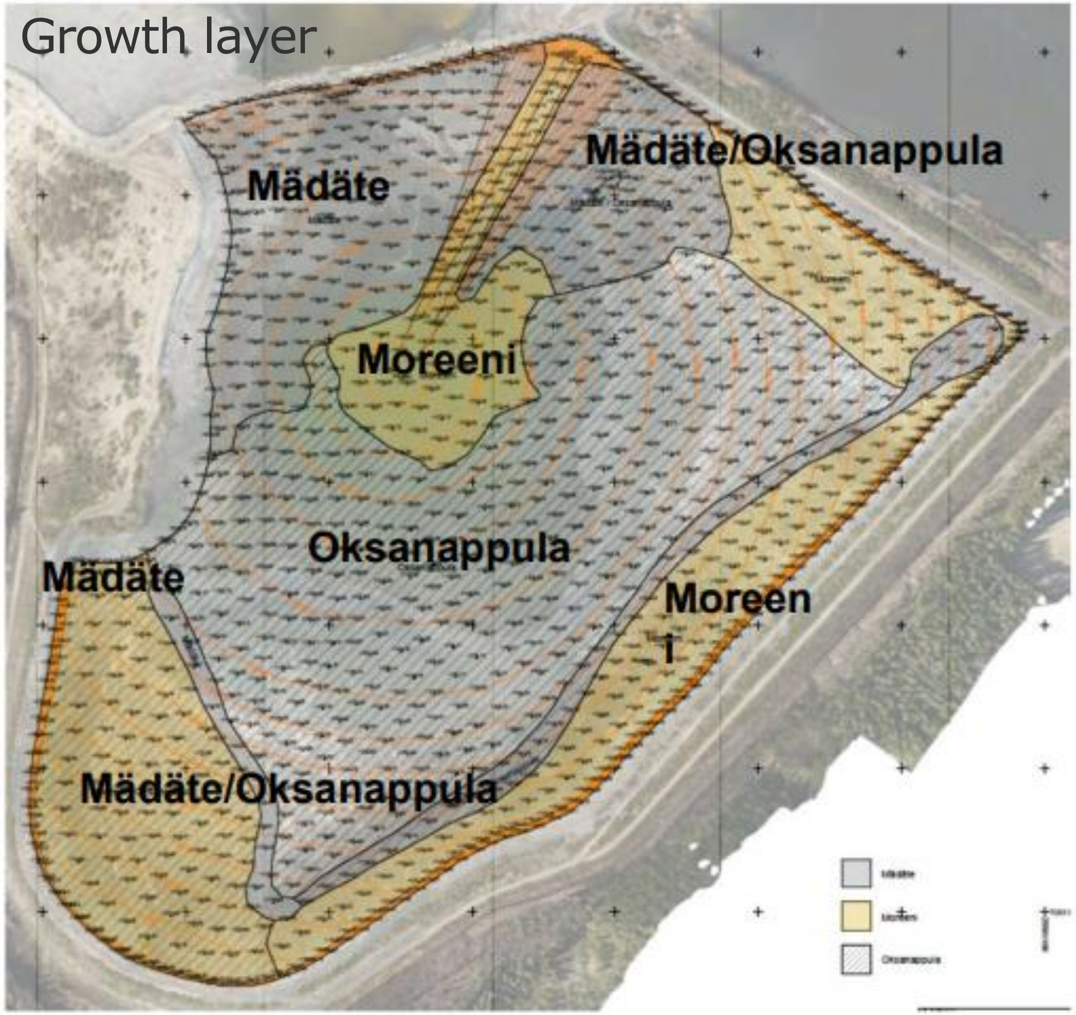


FIBRE CLAY PILOTING IN HITURA 2017-2018

- Hitura 2nd enrichment sand basins sealing layer is partly constructed using fibre clay. Construction was Fortum's responsibility.
- Fibre clay is paper recycling industry's secondary stream.
- Sealing layer must be homogenous and water permeability value $k < 1 \times 10^{-8}$ m/s, layer thickness ≥200 mm and 100 mm growth layer.

FIBRE CLAY PILOTING IN HITURA 2017-2018





RAMBOLL

- Mädäte = waste water sludges digestion
- Oksanappula = branch waste

UPACMIC

FIBRE CLAY PILOTING IN HITURA 2017-2018

Levelled enrichment sand waiting to be covered

Fibre clay from Oulu

Covered fibre clay

RAMBOLL

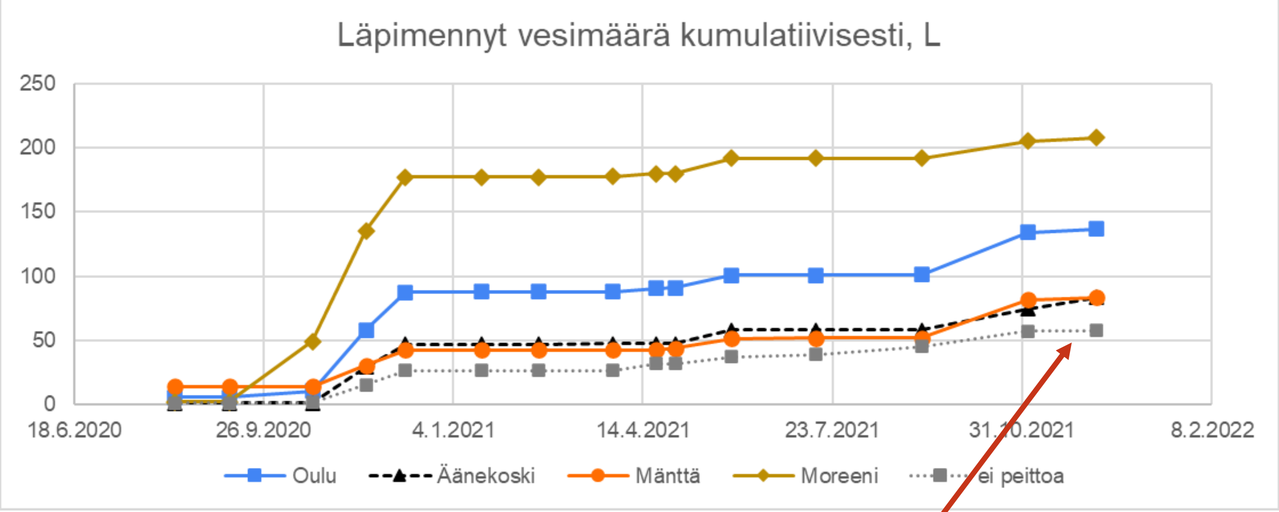
FIBRE CLAY PILOTING IN HITURA 2017-2018

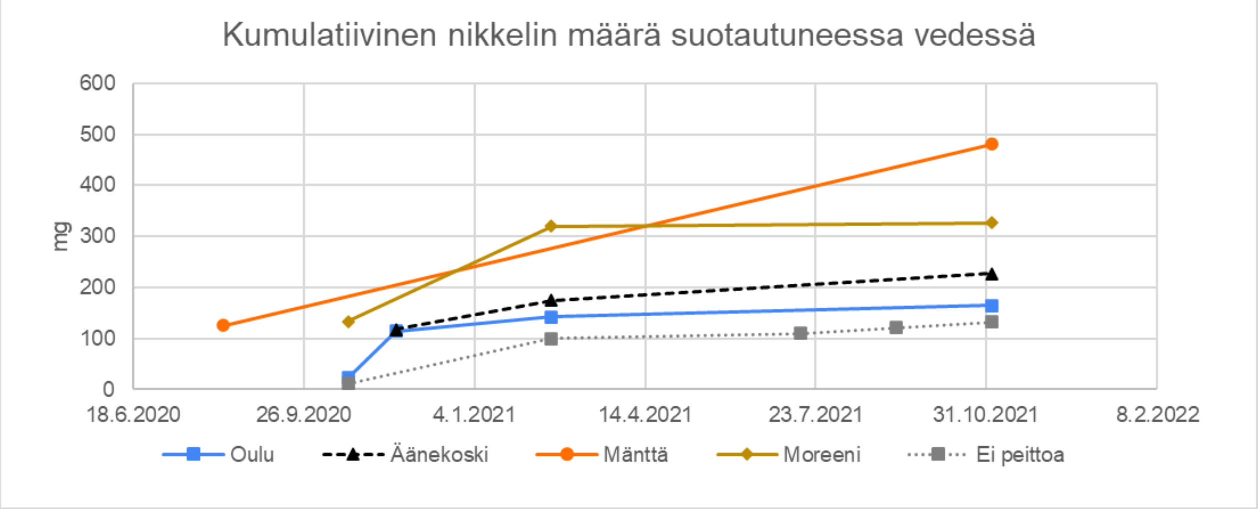
- Compressing of sealing layer was performed by 3 drive over it with tracked excavator.
- After compressing layer thickness was at least 250 mm to overcome materials biodegradation.

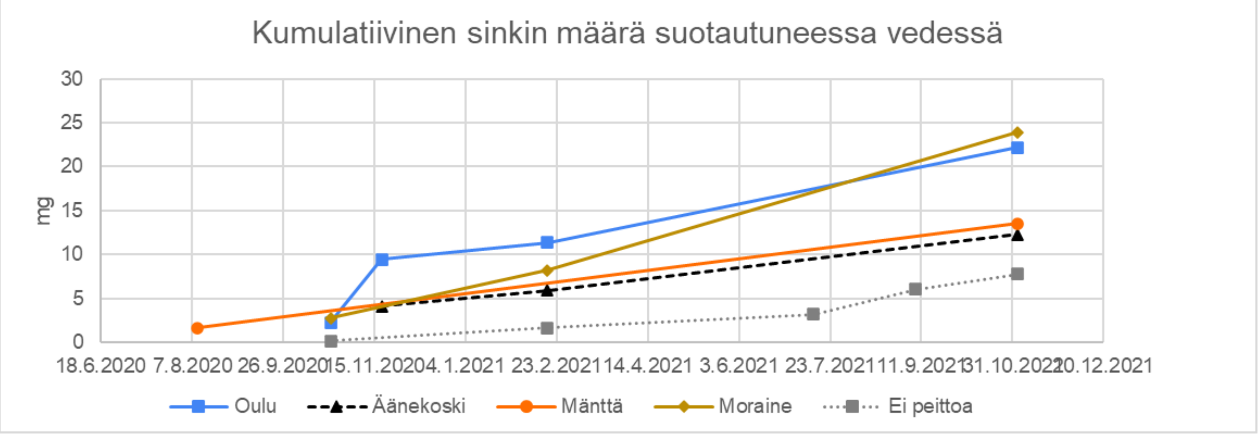
RAMBOLL

FIBRE CLAY FOLLOW UP 2020->

- Follow up has started summer of 2020 and continue. Follow up is executed by GTK and Fortum.







RAMBOLL

KUOPIO VERTICAL SEALING LAYER

- Constructing is tarted autumn of 2020 by Fortum and about half of wall area is constructed in December of 2021. Construction will be continued at spring of 2022.
- The purpose of wall is to prevent water leaching from hazardous waste side to inert waste side of the wall.
- Demanded water permeability value of sealing layer is $k \leq 1 \times 10^{-9}$ m/s.

SEALING- AND DRAINAGE LAYERS

- Sealing layer is constructed by using mould where clay is compressed.
- To achieve demanded permeability value the clay material is compressed 500 mm sections. Mould length is 4m, height is about 1 m and it is 1 m wide.

- Drainage layers are at least 0,5 m wide layer of coarse bottom ash from Riikinvoima Oy.
- Drainage layer is constructed before mould was moved.

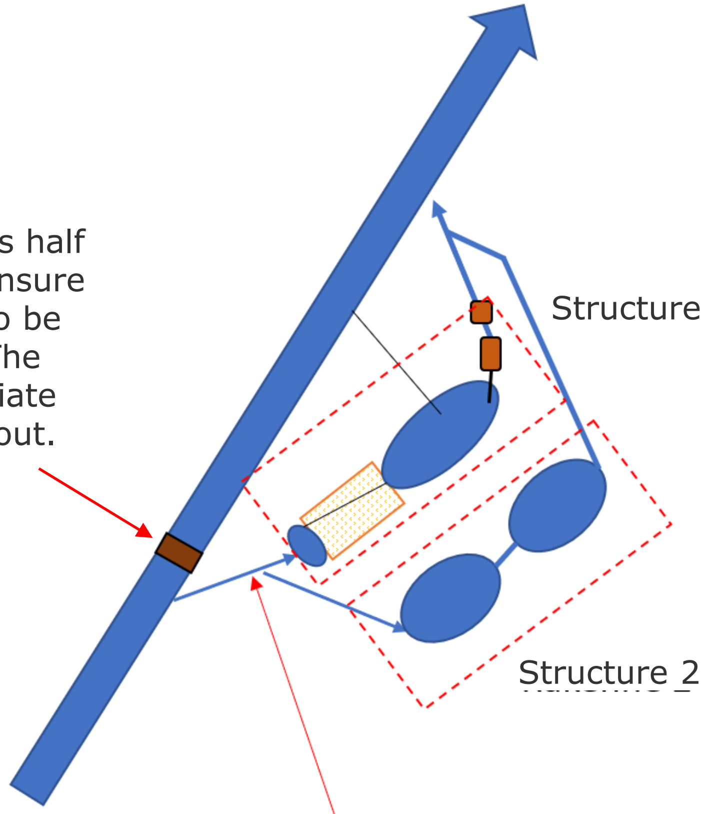
SUPPORT LAYER

- sealing- and drainage layers is supported by 4-6 m wide soil layers, which also were working platform for excavators and dumpers.
- Supporting soils are surplus soils which can be landfilled according its waste class on that side of wall where it is used. Between support and drainage layers is installed N3 class filtration textile, which prevent material mixing.

HITURA SURPLUS SOIL COVER LAYER PILOT IN 2021

- Hitura pre-crushing area is covered as landscaping purpose using surplus soil. Skarta executed this pilot during simmer of 2021.
- Covered area is 33 941 m².
- For covering has used 16 970 m³ clay material.
- Growth layer was also constructed surplus soil from nearby field which take about 3 400 m³ soil.

FILTRATE WATER TREATMENT WITH PASSIVE REACTIVE STRUCTURES 2021



Structure 1:

Two stage pilot with alternative materials. On first stage water pH value is risen by limestone barrier (SMA Minerals). On second step water flows through industrial waste based geopolymer adsorbent which is produced in Oulu university.

Structure 2:

There is two pond arraigned parallel. In the bottom of each pond is reactive mat installed between gravel layers. Mats are submitted by Huesker Synthetic GmbH. Water flows through structure and mats by gravity.

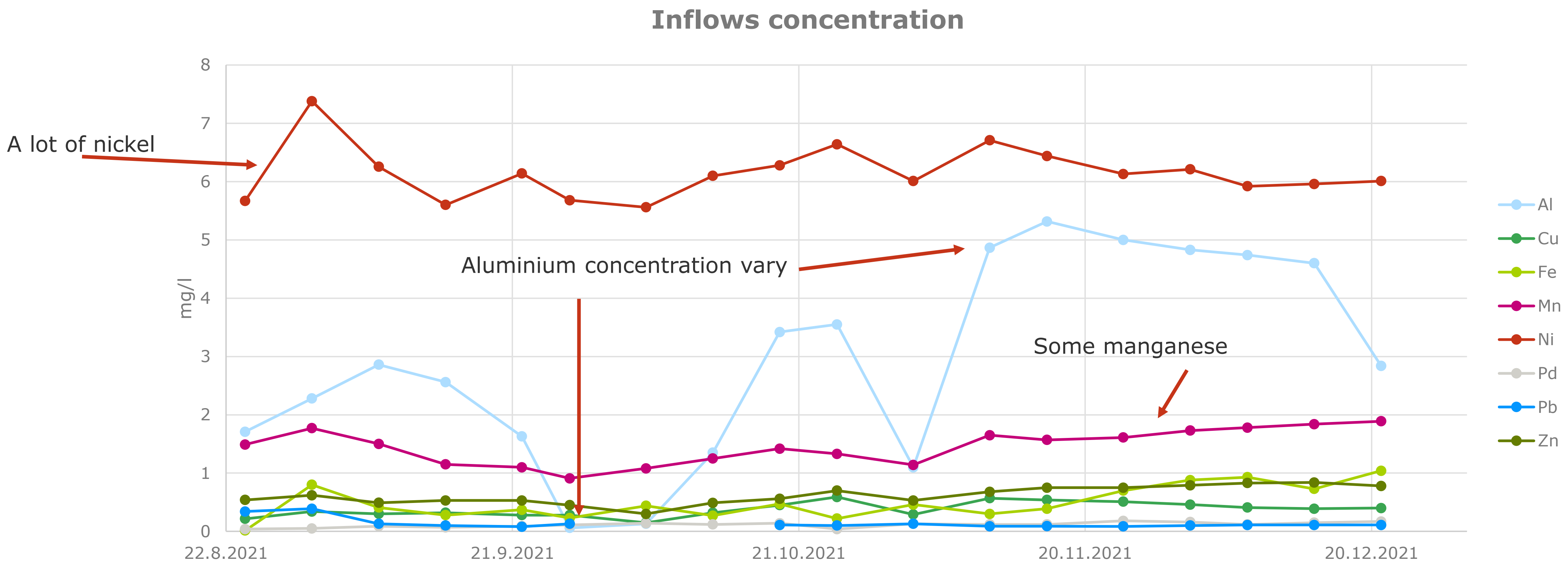
Monitoring by water samples started at august 2021 and it continued to end of the year. 2nd structures follow up continued at summer 2022 after mat changing to conform that mats can be changed without performance loss.

REACTIVE BARRIER AND GEOPOLYMER

RAMBOLL

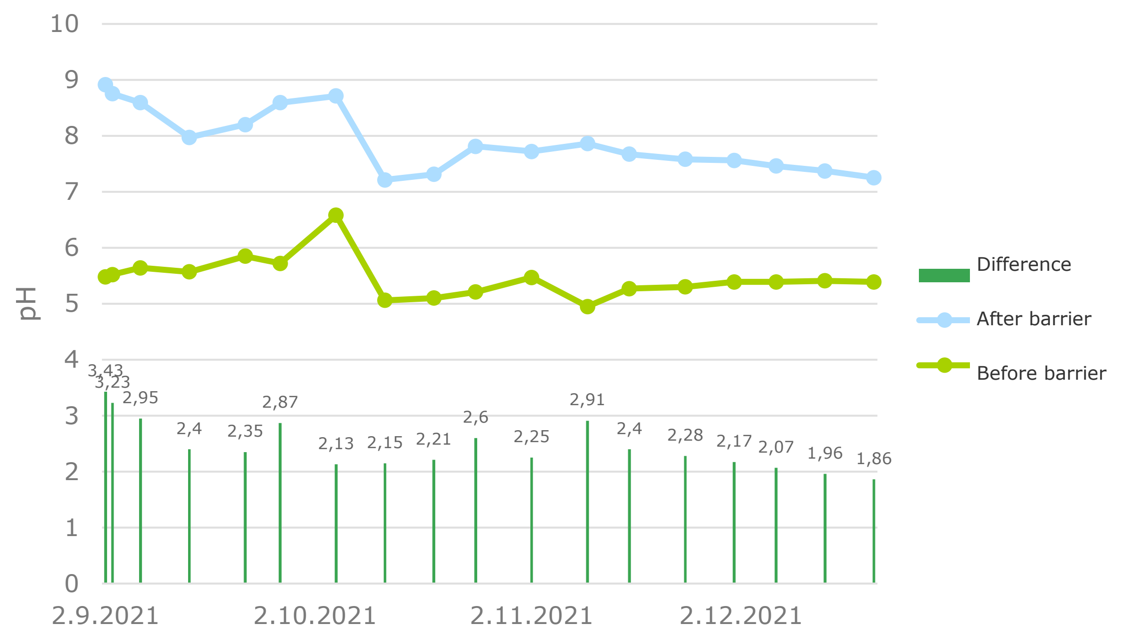

HITACHI
Equalisation pond
Limestone barrier
Geopolymer well
Settling pond
RAMBOLL

REACTIVE STRUCTURES INCOMING WATER

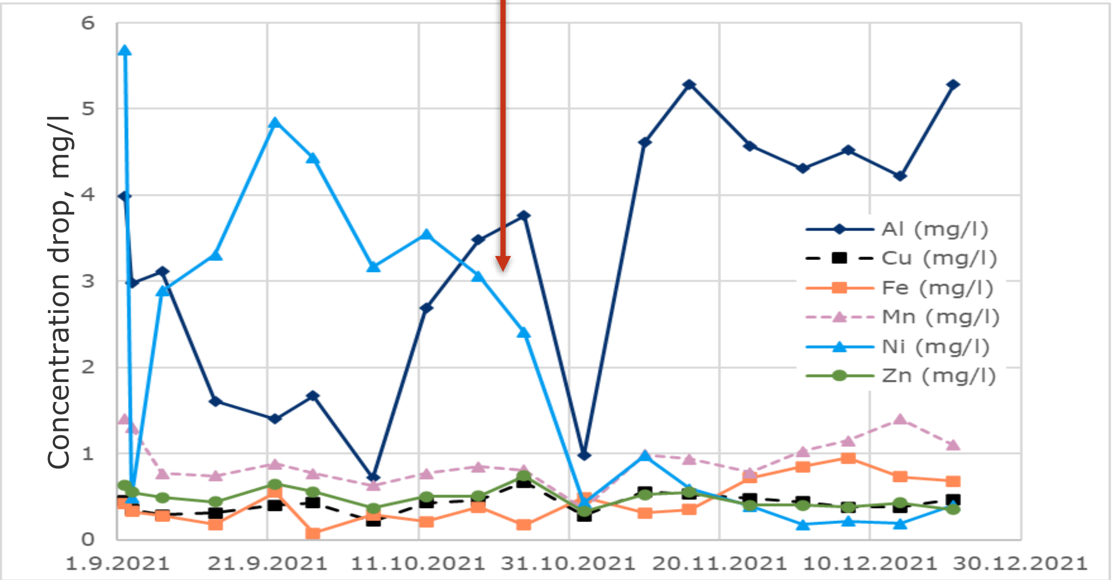


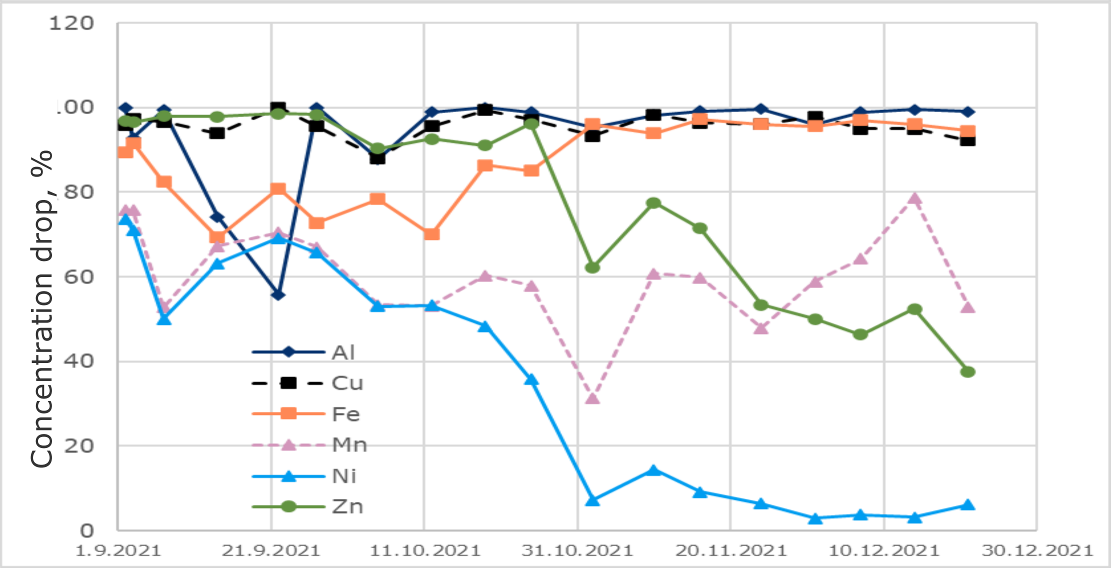
RAMBOLL

LIMESTONE BARIER



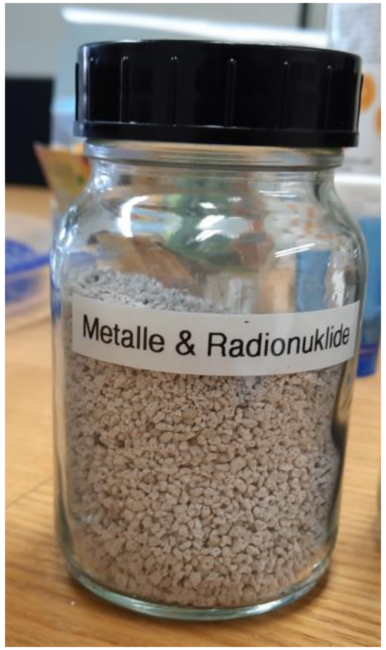
Nickel concentration reduction decline after about 1,5 month

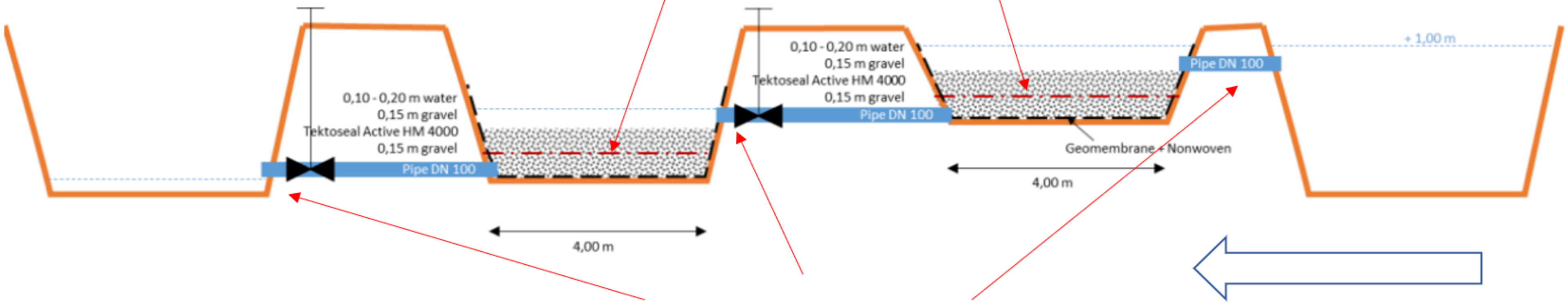




RAMBOLL

REACTIVE MAT PILOT



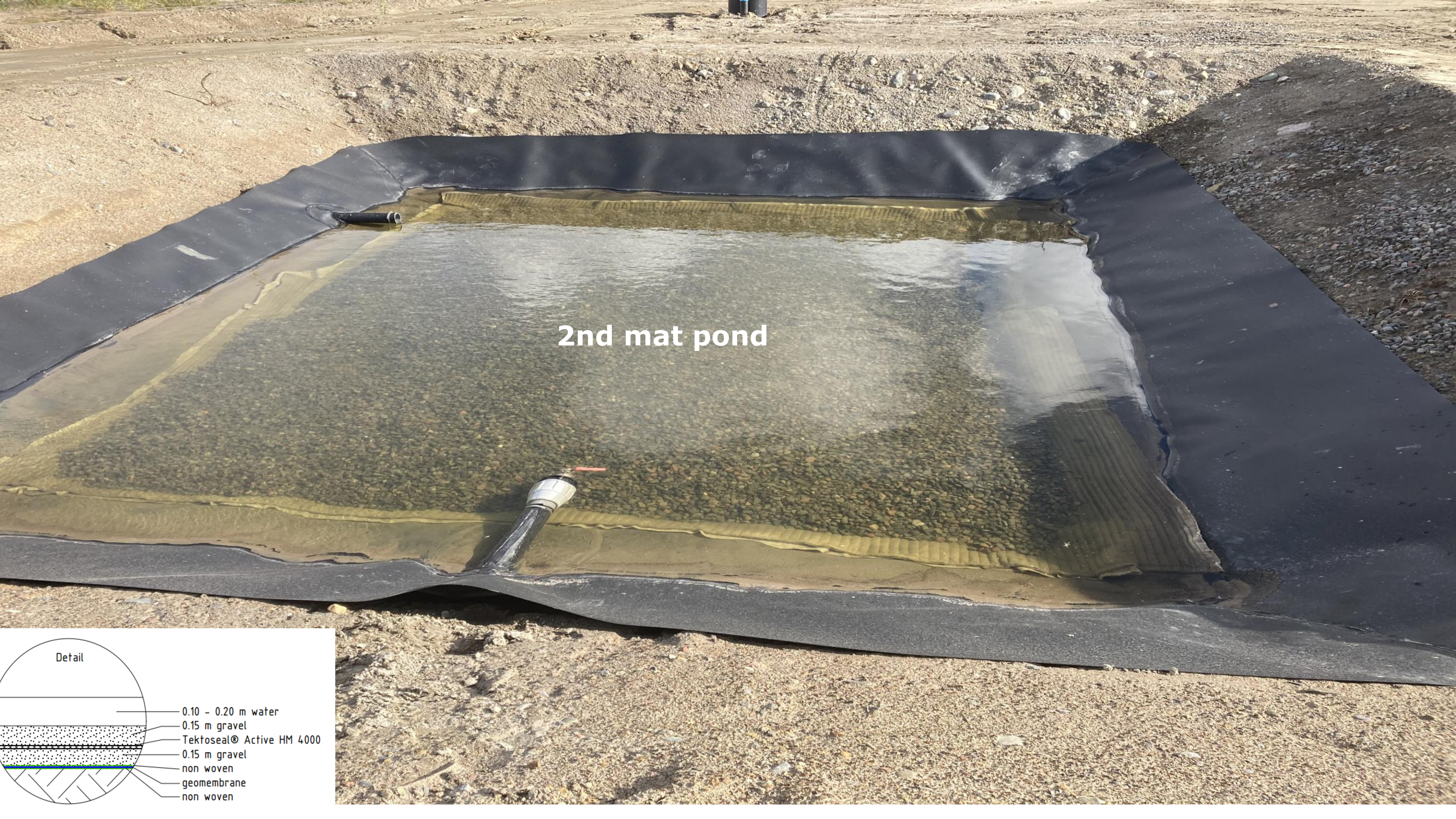


In the structure water infiltrate through mats by gravity.

Tektoseal® Active HM 4000 is geocomposite which consisting of two layers of geotextiles that sandwich a granular cation adsorbent.

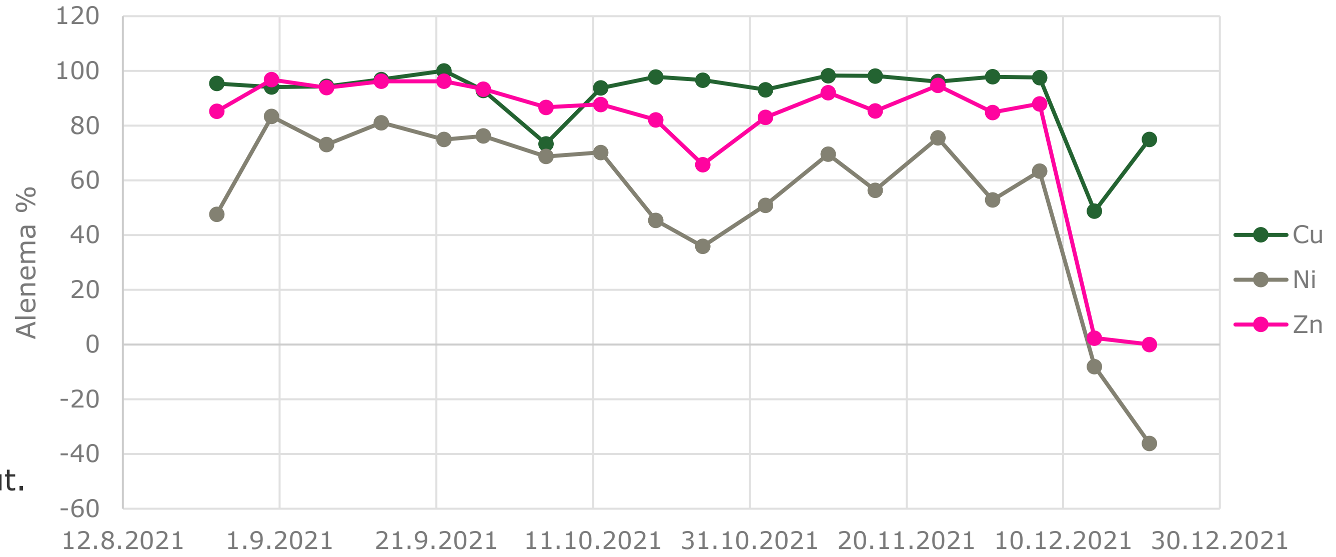
Mat’s producer is Huesker Synthetic GmbH.

Inside the mat is 4000 g of the adsorbent per square meter of the mat. The granular adsorbent is a calcium aluminium silicate.


2nd mat pond
Detail
0.10 - 0.20 m water
0.15 m gravel
Tektoseal® Active HM 4000
0.15 m gravel
non woven
geomembrane
non woven

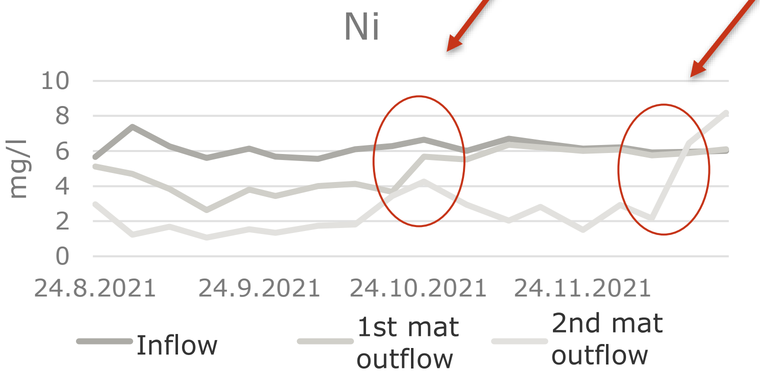
REACTIVE MAT PILOT

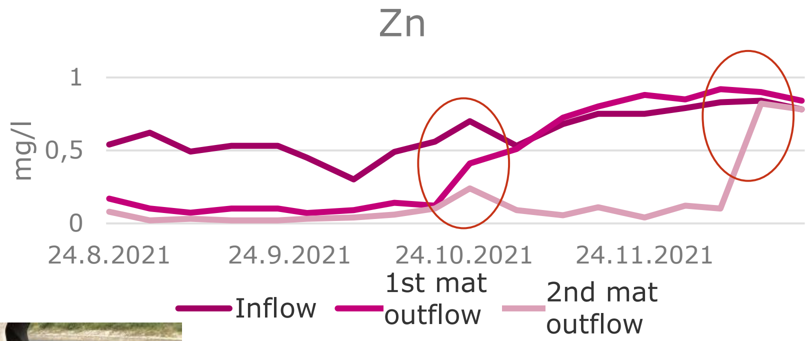
One mat can stand 2 months in test condition.

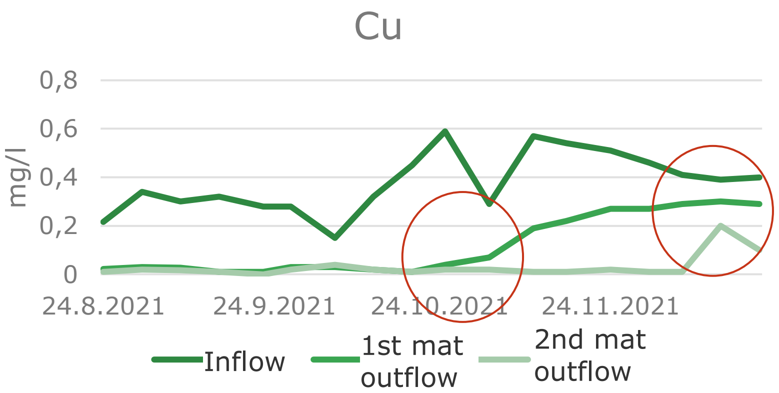


1st mat adsorption capacity runs out.

2nd mat adsorption capacity runs out.







RAMBOLL

RESULTS

SAVED NATURAL RESOURCES

Vertical sealing layer	Layer	Amount (m^3)
Clay from Mäkelän	Sealing	**300**
Clay from Hamulan	Sealing	**1 700**
Ash from Riikinvoima Oy	Drainage	**1 950**
Water treatmet sludge from Hitura	Support	**2 000**
Fly ash from Mondi Powerflute Oy	Support	**2 000**
Waste-/surplus soil	Support	Support layer (includes ash and sludge) **19 500**

Fibre clay	layer	amount (m^3)
Sealing layer (fibre clay)	Sealing	148 850m² x 200 mm = **29 770**
Growth layer (moraine)	Growth	Moraine 5 000 m³ + wood industry aste knots 11 000 m³ + anaerobic dicgestion sludge 10 000 m³ = **26 000**

Sealing structure using surplus clay	layer	Amount (m^3)
Surplus Clay	Sealing	**16 970**
Moraine	Growth	**3 400**

Saved natural aggregates	N. 100 000 m³

RAMBOLL

IMPORTANT LESSON

"Waste from one can be a valuable resource to another"

RAMBOLL

AFTER LIFE

- Pilot structures future
  - Vertical sealing layer is permanent structure and monitoring of it will be continued by Fortum Waste Solutions Oy in accordance with the environmental permit.
  - Fibre clay sealing layer is permanent structure and monitoring of it will be continued by Fortum Waste Solutions Oy according to the requirements of the environmental authority.
  - Pre-crushing sites sealing structure is permanent and monitoring of it is not demanded.
  - Reactive structures testing continues and ownership of test site changes to Feasib Analytics Oy.
    - Other tests can be carried out on the test site.

RAMBOLL

AFTER LIFE

- Result exploitation
  - There is 19 abandoned mine in Finland which need cover structures.
    - Often there is also water problems which needs care.
    - There is great need for climate neutral and cost efficient cover structures and passive water treatment methods.
  - In Finland is planned also some new mines such as Kelibers lithium mine which located in Kaustinen. New mines can learn from UPACMIC-project results.
  - Mining is not just Finland's privilege so results can be scaled up cross the Europe as well.